9-6-14

RETURN TO
SYS. ENGINEERING LAB.
SPACE SYS. DIVISION

INSTRUCTION MANUAL

MODEL 104

10 MC PULSE GENERATOR

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DATAPULSE

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SPACE SYS. DIVISION

INSTRUCTION MANUAL

MODEL 104

10 MC PULSE GENERATOR

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SERIAL NO. _____

Your DATAPULSE Model 104 Pulse Generator is a compact source of very fast repetition rate, yet high power fast rise time pulses. This instrument features full flexibility in repetition rate, delay, width, amplitude and pulse shape.

This manual contains general and detailed instructions for use and maintenance. A complete understanding of its contents will contribute to full utilization of the broad capabilities of this instrument.

DATAPULSE INCORPORATED
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ORchard 1-7713 ORegon 8-3983

October 17,1962

ERRATA & ADDENDUM MODEL 104

Reference Page 1-1 "SPECIFICATIONS", paragraph 1.6

Change first line to read . . . " Continuously variable from 30 ns . . ."

PAGE

SECTION I SPECIFICATIONS

1.1 INTERNAL REPETITION RATE 1-1
1.2 EXTERNAL TRIGGER 1-1
1.3 SINGLE PULSE 1-1
1.4 GATED OPERATION 1-1
1.5 MAIN PULSE DELAY (of leading edge from Sync Output) 1-1
1.6 MAIN PULSE DURATION (at 50% amplitude point) 1-1
1.7 STABILITY, JITTER, AND ACCURACY (delay and duration) 1-1
1.8 MAIN PULSE OUTPUT 1-1
1.9 SYNC OUTPUT 1-1
1.10 DIVIDED SYNC OUTPUT 1-1
1.11 POWER SUPPLIES 1-1
1.12 POWER REQUIRED 1-1
1.13 CONSTRUCTION 1-1
1.14 SIZE AND WEIGHT 1-1
1.15 ACCESSORIES FURNISHED 1-1
1.16 ACCESSORIES AVAILABLE 1-1

SECTION II OPERATING INSTRUCTIONS

2.1 DESCRIPTION OF CONTROLS AND CONNECTORS 2-1
2.2 PLACING IN OPERATION 2-1
2.3 OPERATING CONSIDERATIONS 2-3
2.4 SPECIAL APPLICATIONS 2-5

SECTION III THEORY OF OPERATION

3.1 BLOCK DIAGRAM DESCRIPTION 3-1
3.2 THE ASTABLE MULTIVIBRATOR 3-3
3.3 THE ONE-SHOT MULTIVIBRATOR 3-3
3.4 TRANSFORMER COUPLED AMPLIFIER 3-3
3.5 PULSE FORMING CIRCUITS 3-4
3.6 OUTPUT AMPLIFIER 3-4
3.7 THE +100 REGULATOR 3-4
3.8 THE +225 AND +130 REGULATORS 3-5
3.9 THE POWER SUPPLY PROTECTION CIRCUITRY 3-5
3.10 THE DIVIDED SYNC BLOCKING OSCILLATOR 3-6

SECTION IV MAINTENANCE INSTRUCTIONS

4.1 PREVENTIVE MAINTENANCE 4-1
4.2 PARTS REMOVAL AND REPLACEMENT 4-1
4.3 TROUBLESHOOTING PROCEDURE 4-2
4.4 CALIBRATION PROCEDURE 4-8
4.5 SPECIFICATIONS VERIFICATION 4-14

SCHEMATICS

DRAWING NO.:	TITLE	
40000-007	SCHEMATIC -- S1 OSCILLATOR RANGE SWITCH	4-17
40000-008	SCHEMATIC -- S4 PULSE DELAY SWITCH	4-18
40000-009	SCHEMATIC -- S5 PULSE WIDTH SWITCH	4-19
40000-027	SCHEMATIC -- ATTENUATOR, 60 DB	4-21
40000-010	SCHEMATIC -- POWER SUPPLY	4-23
40000-006	SCHEMATIC -- 10 MC PULSE GENERATOR	4-25

WARRANTY

INSTRUMENT CERTIFICATION

LIST OF ILLUSTRATIONS

Figure	Title
2-1	Front Panel Controls
2-2	Rear Panel Controls
2-3	Output Pulse
2-4	Pos. Output Pulse into 10 Ohms
2-5	High Impedance Amplitude Control
2-6	Five Megacycle Square Wave
2-7	Wiring for Multiple Pulse Output
2-8	Double Pulse Output from Two Units
2-9	Pos. Pulse Improperly Terminated
2-10	Poor Sync Connection Technique
2-11	Proper Cabling Connection
2-12	Pos. Pulse with Baseline at +50 mv
2-13	Wiring for DC Offset Power Supply
2-14	Pos. Pulse with Baseline at +1 mv
3-1	Signal Test Points
3-2	The Astable Multivibrator
3-3	Cathode Coupled Multivibrator
3-4	Two Stages of Trigger Amplification
3-5	Simplified Pulse Forming Circuits
3-6	Output Amplifier Section
3-7	Simplified Regulator (+100v)
3-8	Simplified Regulator (+225v and +130v)
3-9	Current Limiting Circuit
3-10	Overvoltage Protection
3-11	Divided Sync Blocking Oscillator
4-1	Circuit Locations
4-2	Possible Sources of Malfunction
4-3	Waveform Analysis in Troubleshooting
4-4	Power Supply Adjustments & Test Points
4-5	Repetition Rate Calibration Controls
4-6	Waveform Calibration
4-7	Output Waveform Adjustments (Top)
4-8	Output Waveform Adjustments (Bottom)
4-9	Pulse Delay and Width Adjustments

LIST OF TABLES

Table		Section
I	Tube Voltage and Resistance	4.3
II	Transistor Voltage and Resistance	4.3
III	Power Transformer Voltages	4.3
IV	Voltage Calibration	4.4
V	Pulse Delay Calibration	4.4
VI	Pulse Width Calibration	4.4
VII	Repetition Rate Calibration Check	4.5
VIII	External and Single Triggering Check	4.5
IX	Pulse Delay Calibration Check	4.5
X	Pulse Width Calibration Check	4.5

SPECIFICATIONS

1.1 INTERNAL REPETITION RATE

Continuously variable from 5 cps to 10 mc, covered in 19 steps (1, 2, 5 series) plus uncalibrated vernier. Step accuracy is approx. 10% with vernier at maximum; jitter is typically less than 0.02%.

1.2 EXTERNAL TRIGGER

Requires 5v pos. pulse, or neg. pulse with accessory inverting transformers, with less than 30 nanosec. rise time (30 nanosec. minimum duration) at 0 to 10 mc, or 5v rms sine wave at 10 cps to 1 mc. Unit may be easily modified to trigger from pos. 3v pulses with durations as short as 10 nanosec. Sync Output occurs approx. 50 nanosec. following external trigger.

1.3 SINGLE PULSE

Operation of front panel pushbutton provides one cycle of output.

1.4 GATED OPERATION

Outputs may be gated off by an external control signal of zero volts or less, and gated on with pos. 20v or more. Gate input impedance is 100k; gate response time is approx. 0.1 microsec. (Asynchronous gating signals may cause variation in waveform and amplitude of first and last pulses gated through.)

1.5 MAIN PULSE DELAY (of leading edge from Sync Output)

Continuously variable from 50 nanosec. to 10 millisec., covered in 14 steps (1, 2, 5 series) plus uncalibrated vernier, at least 70% max. duty cycle.

1.6 MAIN PULSE DURATION (at 50% Amplitude Point)

Continuously variable from 20 nanosec. to 500 microsec., covered in 10 steps (1, 2, 5 series) plus uncalibrated vernier. See Main Pulse Output for duty cycle limitation.

1.7 STABILITY, JITTER AND ACCURACY (Pulse Period, Pulse Delay and Pulse width)

Stability* is ±2 1/2%; jitter is typically less than 0.1%; step control accuracy is approx. 5%.

1.8 MAIN PULSE OUTPUT

Selectable positive, zero, or negative, dc coupled with baseline nominally at ground (at max. output with 50-ohm load; within 5 mv of ground on negative, within 500 mv on positive). UHF connector (SO 239).

1.8.1 Amplitude: At least 40v peak into 50 ohms** (approx. +60v, -100v open circuit). Continuously variable, zero to 60db attenuation is provided covered in 2-db and 10-db steps (approx. 10% accuracy) plus uncalibrated vernier. Stability* is approx. ±5%.

**at repetition rates to 8 mc, decreasing less than 10% at 10 mc

1.8.2 Waveform (with 50-ohm load): Rise time (leading edge) is continuously variable from approx. 10 to 200 nanosec.; fall time (trailing edge) is approx. equal to rise time. Overshoot variation is adjustable to less than 5%; top slope is less than 3%. At output attenuations greater than 30 db, min. rise time and overshoot increase somewhat.

1.8.3 Duty Cycle and Overload Protection: Average output current in excess of approx. 300 ma operates a panel indicator lamp and activates protection circuits to decrease output amplitude to a safe level. Removal of overload automatically returns circuit to normal.

1.9 SYNC OUTPUT

Provided at two amplitudes - pos. 1v or 10v into 100 ohms, approx. 30 nanosec. duration, ac coupled.

1.10 DIVIDED SYNC OUTPUT

A synchronized subharmonic of the Sync Output provided at approx. 2 mc when the instrument is operated above that rate. Pos. 8v into 100 ohms, approx. 30 nanosec. duration, ac coupled.

1.11 POWER SUPPLIES

All dc power supplies are fully regulated for stable operation under varying conditions of load or line voltage.

1.12 POWER REQUIRED

105-125v, 50/60 cycle ac, approx. 500 watts. 220v, 50/60 cycle operation may be specified at no added cost.

1.13 CONSTRUCTION

Light-gold anodized front panel with etched black and red markings; beige cabinet with quick-release top and bottom covers; forced air cooling with filter. Unless otherwise noted all connectors BNC.

1.14 SIZE AND WEIGHT

8 3/4" H x 17" W x 15 1/4" D. May be rack mounted (8 3/4" H x 19" W panel space) by specifying model 104R or by adding one Type 1002 Rack Mounting Set, available as an accessory item. Weight is approx. 45 lbs.

1.15 ACCESSORIES FURNISHED

One operation and maintenance manual; 8 ft. line cord with NEMA 3-prong plug.

1.16 ACCESSORIES AVAILABLE

Coaxial cables; 50-ohm power termination (type 2002); trigger pulse inverting transformer (type 2101).

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* Stability is stated as typical change with line voltage variation of ±10v around 115v. Line voltage transients have negligible effect on pulse timing and amplitude.

OPERATING INSTRUCTIONS

2.1 DESCRIPTION OF CONTROLS AND CONNECTORS

See Figures 2-1 and 2-2.

2.1.1 Power On-Off: The line power applied to the instrument is controlled by this toggle switch.

2.1.2 Pilot: The green indicator is illuminated when the power is ON.

2.1.3 Repetition Rate: The black outer knob selects the range of pulse repetition frequency. There are 19 PRF ranges which increase according to a 1, 2, 5 progression. The EXT. position permits external triggering.

2.1.4 Repetition Rate Vernier: The red inner control provides 300° of continuously variable fill-in between the ranges of the REPETITION RATE control.

2.1.5 Single Pulse: Each depression of the push-button initiates one cycle of output when the REPETITION RATE control is on EXT.

2.1.6 Pos. External Trigger Input: This BNC connector accepts a 5v pulse or sine wave to slave the generator when the REPETITION RATE control is in the EXT. position.

2.1.7 Positive Sync Output:

10-volt: This BNC connector couples out a 10v positive pulse which serves as a zero time reference for the main pulse delay.

1-volt: The BNC connector couples out the same signal as above, only attenuated to facilitate triggering transistor circuitry.

2.1.8 Divided Sync Pos. Output: This BNC connector couples out an 8v positive pulse at approximately 1 to 2 mc, but synchronized with the POSITIVE SYNC OUTPUT.

2.1.9 Division Adjust - Off: This 300° continuously variable control permits the DIVIDED SYNC POS. OUTPUT to be synchronized with the POSITIVE SYNC OUTPUT. In the extreme counterclockwise position the DIVIDED SYNC POS. OUTPUT signal may be turned off.

2.1.10 Pulse Delay: The black inner control selects the range of pulse delay. There are 14 delay ranges which increase according to 1, 2, progression.

2.1.11 Pulse Delay Vernier: The red outer knob provides 300° of continuously variable fill-in between the ranges of the PULSE DELAY control.

2.1.12 Pulse Width: The black inner control selects the range of pulse width. There are ten width ranges which increase according to a 1, 2, 5 progression.

2.1.13 Pulse Width Vernier: The red outer knob provides 300° of continuously variable fill-in between the ranges of the PULSE WIDTH control.

2.1.14 Polarity: The black outer knob allows the main pulse output to be positive, negative, or zero.

2.1.15 Rise Time: This red inner knob provides 300° of continuous control over rise (and fall) time of both polarity pulses. It may also be used as an "overshoot" trim.

2.1.16 Attenuation 0-50 db: This 60° selector attenuates the main pulse output signal up to 50 db in six 10-db steps.

2.1.17 Attenuation 0-10 db: The black outer knob attenuates the main output pulse up to 10 db in six 2-db steps.

2.1.18 Attenuation Vernier: The red inner knob provides 300° of continuously variable fill-in between the steps of the 0-10 db attenuator.

2.1.19 Pulse Output Z_o = 50Ω: This UHF connector direct couples out the main output pulse.

2.1.20 Average Pulse Current Overload: When illuminated this red light indicates that the maximum average current limitation has been exceeded. To correct, reduce the repetition rate or the pulse width.

2.1.21 Positive Gate Input: This BNC connector accommodates the external gating signal. When the dc level of this signal is zero or less, the generator output signals are shut off. They are gated on with a positive 20v signal.

2.1.22 Gated-Not Gated: This toggle switch determines whether or not the outputs are to be controlled by a signal at the POSITIVE GATE INPUT.

2.1.23 Line Fuse - 5A (located on rear panel): A 5-amp fast acting fuse protects the instrument against ac overload.

2.1.24 +225 Fuse - 1/2A (located on rear panel): A 1/2-amp fast acting fuse protects the +225v regulator against overload.

2.1.25 +130 Fuse - 1/2A (located on rear panel): A 1/2-amp fast acting fuse protects the +130v regulator against overload.

2.1.26 Power Input (located on rear panel): This 3-prong recessed male connector accommodates a NEMA 3-wire line cord.

2.2 PLACING IN OPERATION

2.2.1 Preliminary Settings:

a. REPETITION RATE control to 0.1 MC/S: REP. RATE VERNIER clockwise (cw)

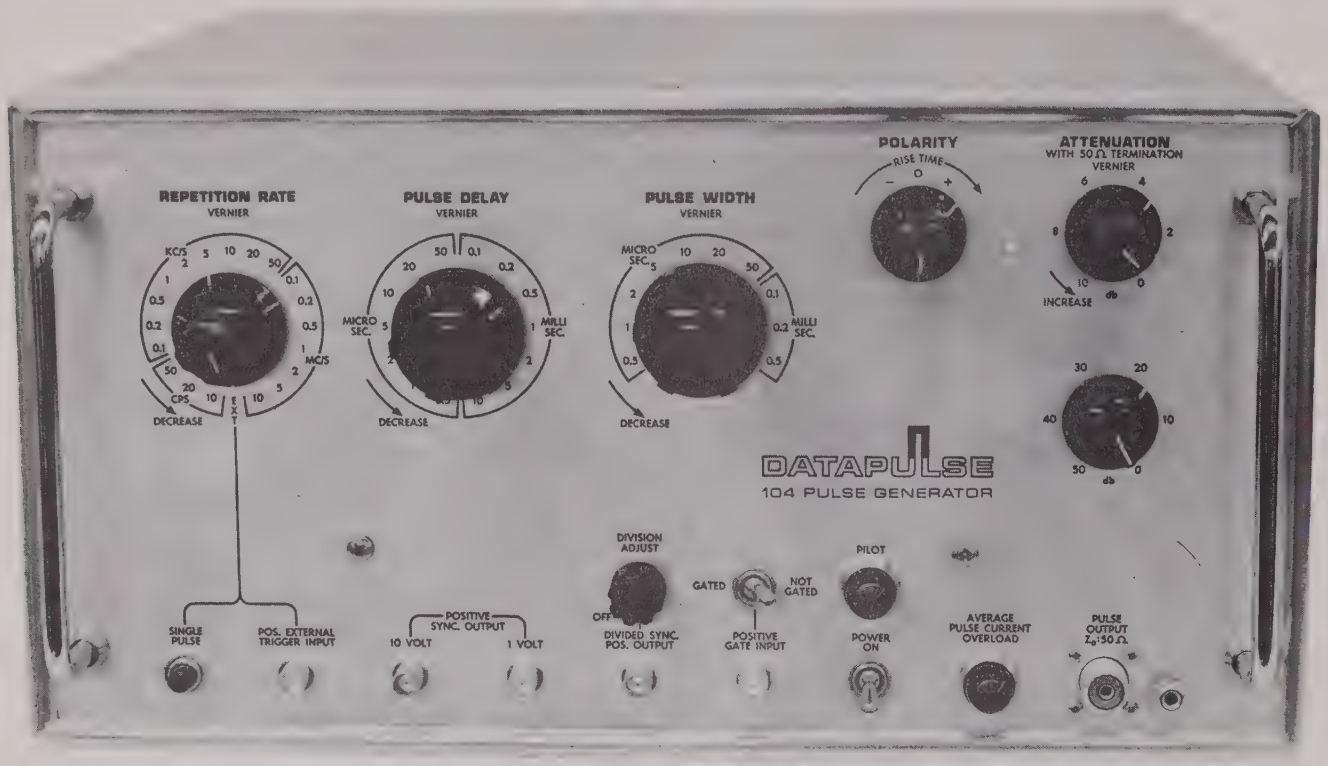


Figure 2-1. Front Panel Controls

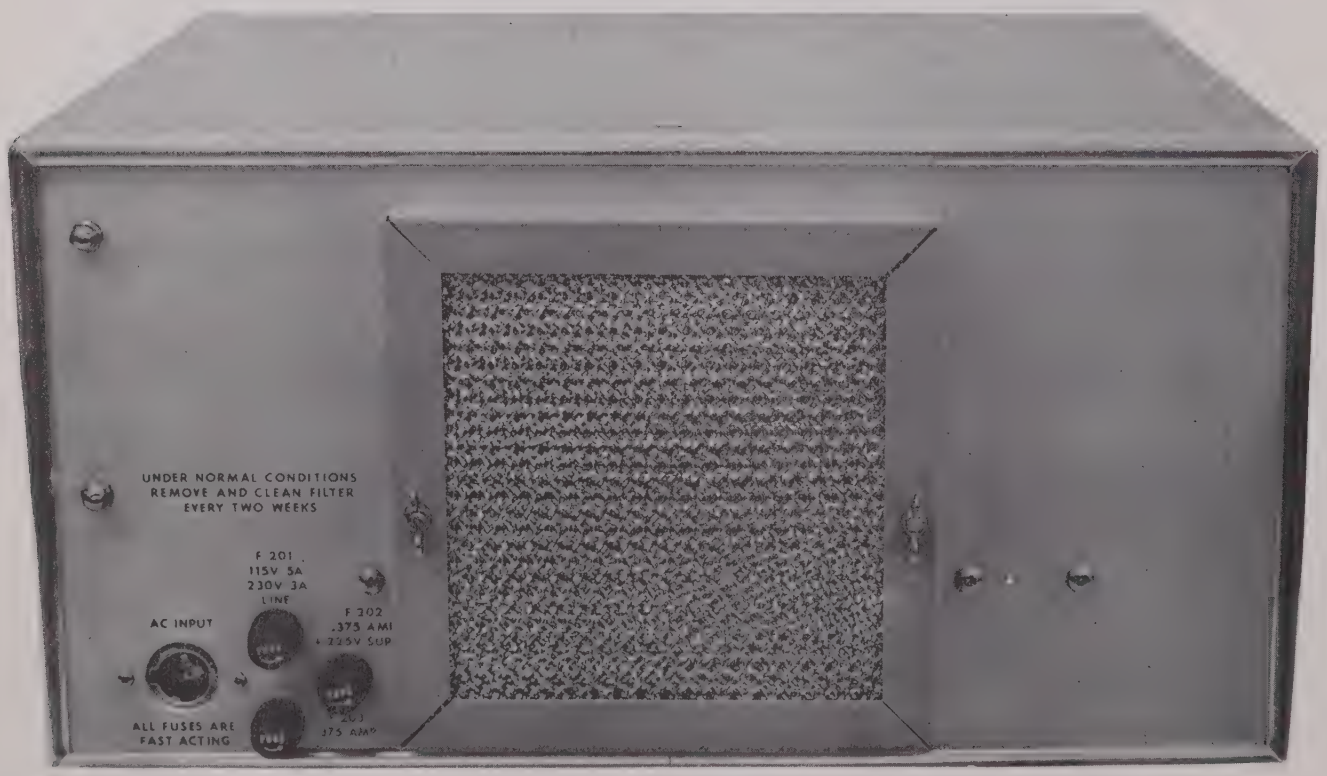


Figure 2-2. Rear Panel Controls

2.2.1 Preliminary Settings - continued.

b. PULSE DELAY control to 0.5 microsec.; DELAY VERNIER counterclockwise (ccw).
c. PULSE WIDTH control to 0.5 microsec.; WIDTH VERNIER cw.
d. POLARITY switch to "+"; RISE TIME control ccw.
e. GATED-NOT GATED switch on NOT GATED.
f. Each ATTENUATION control on "0" db; attenuation VERNIER cw.
g. Terminate output pulse into 50 ohms.

2.2.2 Set POWER switch to ON. PILOT should light.

2.2.3 Sync scope from POSITIVE SYNC OUTPUT. Set scope sweep speed to 0.1 μs/cm; set vertical sensitivity to 20v/cm.

2.2.4 Observe the output pulse against that shown in Figure 2-3. Refer to the Troubleshooting Procedure, paragraph 4.2, if the unit does not function properly.

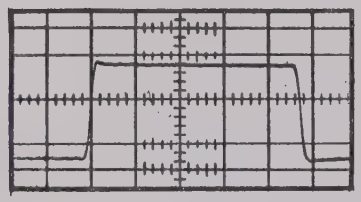


Figure 2-3 Output Pulse
0.5 Microsec. Wide
Viewed on Tektronix Type 541 Oscilloscope

2.3 OPERATING CONSIDERATIONS

2.3.1 Single Pulse Operation: Place REPETITION RATE control on EXT prior to depressing button. Maximum single pulse rate is one per second.

2.3.2 External Triggering: REPETITION RATE control must be on EXT. Maximum repetition rate is 10 mc.

2.3.3 Oscillator Starting: Sometimes the oscillator will not start when the REPETITION RATE control is at 10 mc and the REP. RATE VERNIER is fully clockwise. Turn the VERNIER about 10° counter clockwise to start the oscillator.

2.3.4 Oscillator Stability: Pulse repetition frequency may vary as much as ± 7% with line voltage excursion from 105 to 125v ac.

2.3.5 Interaction: The delay or the width circuits will interact slightly with the oscillator at about half period time. Interaction is typically less than 1% below 1 mc; less than 5% at 5 mc.

2.3.6 Delay Duty Cycle: Delay circuits may fail at PULSE DELAY control settings greater than 70% of the main pulse period.

2.3.7 Width Duty Cycle: Pulse width circuits may fail at PULSE WIDTH control settings greater than 70% of the main pulse period. Also, any combination of pulse width and PRF which causes delivery of over 300 ma to the external load and/or to the internal attenuator will cause the power supply to current-limit at this level. This condition is signaled by the AVERAGE PULSE CURRENT OVERLOAD indicator. It does not damage the instrument to operate indefinitely in this mode; however, the output pulse amplitude will be markedly retarded and will display considerably less stability with line voltage variation.

2.3.8 Overshoot: The RISE TIME control may be used to trim out overshoot and optimize waveform.

2.3.9 Power Switch: An output may not occur if the instrument is turned on and off and back on rapidly. Wait at least two seconds after turn-off before restoring ac power.

2.3.10 Cooling: The bottom dust cover must be in place to provide adequate cooling. Maintain a clearance of at least three inches at the back of the rear air intake, and be sure to clean the air filter at regular intervals.

2.3.11 High Current Output into Low Impedance Loads When operating into a 50-ohm load, the Model 104 provides peak output current slightly less than one ampere. Certain applications, such as magnetic device evaluation or drive of many paralleled digital circuits, require higher output current into lower impedance loads. The standard instrument, without modification or readjustment of internal controls, will provide up to ±14 volts into a 10-ohm load--or 1.4 amperes peak. This performance may be achieved up to pulse width duty cycles of approximately 4%; up to approx. 10% if operated at correspondingly reduced amplitudes (due to action of overload circuitry). For best waveform, it will be necessary to deteriorate the rise time to 12 or 14 nanoseconds and to readjust the internal flat top adjustment.

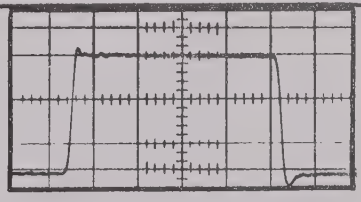


Figure 2-4. Pos. Output Pulse into 10 Ω on Tektronix 541 5v/cm; 0.1 μs/cm.

2.3.12 Square Wave Generation: Model 104 performance is specified as operated into a 50-ohm load with power supplies adjusted to provide an output of 40 volts peak amplitude at average currents up to 300 ma. This, in effect, limits the output pulse width duty cycle to 38% when working with a 50-ohm load. This limitation cannot be extended, as would appear at first glance, by reducing output amplitude with the attenuation controls. The instrument will continue to generate its full output while the output amplitude (including fill-in between steps) is reduced. A portion of the output amplitude is drained off before it reaches the output jack by a constant impedance attenuator.

Some applications, such as frequency response testing with pulse or square wave techniques and gating applications, require pulse width duty cycles in excess of this 38% limitation. Many of these requirements can be met, due to the 104's inherent capabilities, if the unit is operated into higher impedance loads.

The standard instrument, unmodified and as normally adjusted by the factory, can provide positive going square waves of 60 volts peak-to-peak amplitude into loads of 800 ohms and higher. When the instrument is operated in this fashion, the minimum fall time (trailing edge transition time) is increased to approximately 0.1 microsec.; rise time must usually be deteriorated to at least 15 nanosec. for maintenance of clean waveform; maximum repetition rate for square wave generation is approximately 5 mc -- and care must be taken to drive the load through a short cable or line with characteristic impedance approximately the same as load impedance. Also, the internal attenuation may not be used for amplitude control because its output impedance of 50 ohms will cause the instrument to go into overload protection. For amplitude control, a circuit such as shown in Figure 2-5 is necessary.

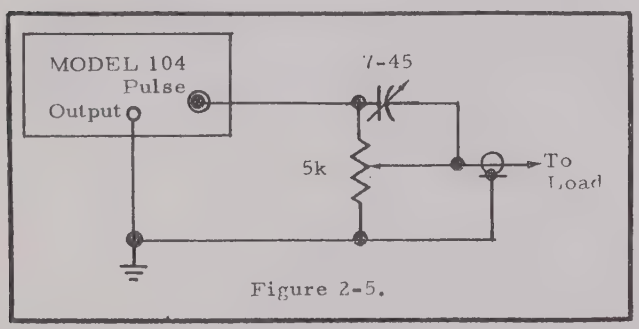


Figure 2-5.

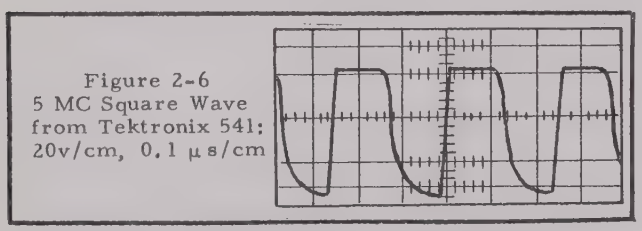


Figure 2-6
5 MC Square Wave
from Tektronix 541;
20v/cm, 0.1 μs/cm

2.3.13 Multiple Pulse or Pulse Train Operation Using Several Model 104s.

Magnetic device testing, beacon development, and digital or other pulse code simulation often require multiple pulse or pulse train signals. Multiple DATAPULSE 104 Pulse Generators, when properly connected, will satisfy a broad range of requirements of this type.

Mixing the outputs of several 104s, instead of purchasing a special purpose multi-pulse generator, offers many advantages. First, pulse parameters may be controlled individually; second, all pulses are selectable in polarity -- a feature not always available on multi-pulse generators; third, average power is greater than in most special units; fourth, such an arrangement is more versatile since the individual units may be broken down for use on other projects; and fifth, the combination of simple, proven easily operated 104's is more dependable than complex special gear.

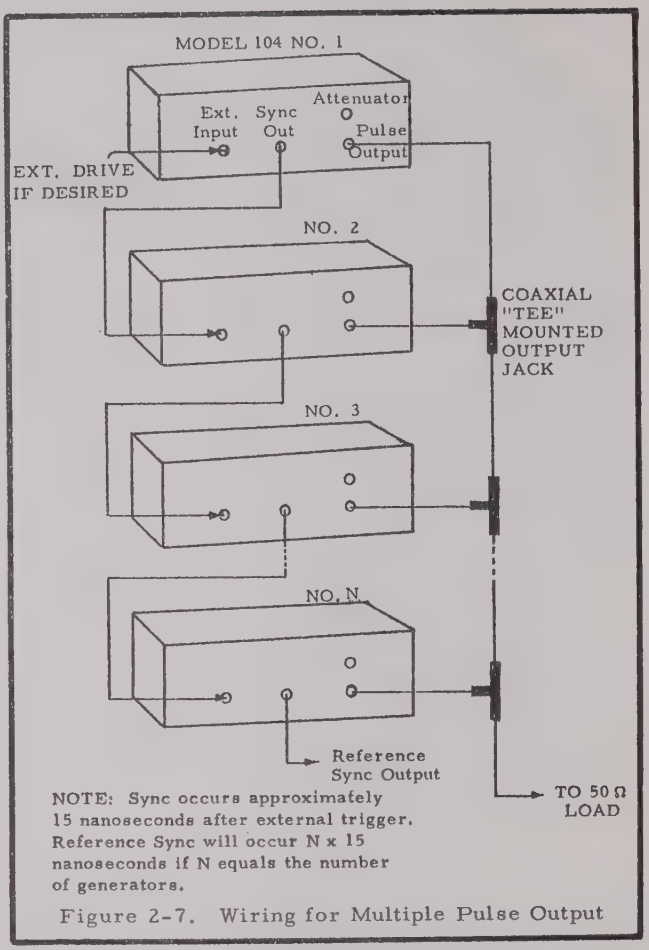

MODEL 104 NO. 1
Ext. Input
Sync Out
Attenuator
Pulse Output
EXT. DRIVE IF DESIRED
NO. 2
NO. 3
NO. N
COAXIAL "TEE" MOUNTED OUTPUT JACK
Reference Sync Output
TO 50 Ω LOAD
NOTE: Sync occurs approximately 15 nanoseconds after external trigger. Reference Sync will occur N x 15 nanoseconds if N equals the number of generators.

Figure 2-7. Wiring for Multiple Pulse Output

The 104s may be driven in parallel from an external source, if sync with outside phenomena is desired, or driven in tandem (see Figure 2-7) using the sync output of one generator to externally drive the next. The first generator may be driven from an external source in the tandem arrangement also. Because of the fast rise character of the pulses and narrow widths available, pulse repetition rates approaching 20 mc may be synthesized.

The termination of interconnecting cables has an important effect on output waveform in this arrangement. Improper termination causes reflections which deteriorate wave shape and increase the rise time. However, excellent waveform fidelity can be obtained (see Figure 2-8), by inserting some measure of attenuation (the amount varying with the number of generators) at the generator end with the internal attenuator. The 50 ohm output impedance of the attenuator tends to terminate the interconnecting cables. The greatly decreased waveform distortion more than offsets the slight loss of amplitude sustained.

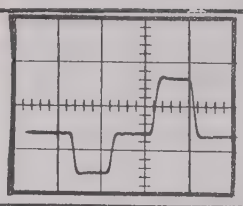
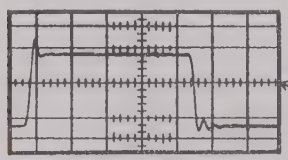


Figure 2-8. Double Pulse Output from Two Units. Tektronix 541. 20v/cm 0.1μs/cm. Each output attenuated 4 db.

2.3.14 Pulse Top Saturation Oscillations: Because of the limited cathode emission of the output tubes the output pulse amplitude will vary somewhat as a function of pulse width duty cycle. For this reason the top of the pulse may be below, on the threshold, or well into the saturation region of the output tubes as a function of duty cycle.

When the pulse top is at the saturation threshold it is unstable and oscillations occur. Turning in about 1/2 db of attenuation on the ATTENUATION VERNIER will suppress this effect.

2.3.15 Cabling Considerations: Delivery of clean waveforms can be assured if good cabling practices are observed. The sync pulse should be connected to the scope and/or the system under test with 93 ohm coaxial cable. This line should be terminated into 93 ohms at the scope. The main pulse should be connected to the load via a 50 ohm coaxial cable and terminated into 50 ohms at the load.



From Tektronix 541 with vert. deflection 20v/cm and sweep speed 0.1μs/cm

Figure 2-9. Pos. Pulse Connected to Scope with 4' RG-58A/U, Terminated in 50Ω at Generator.

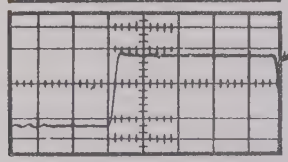


Figure 2-10. Pos. Pulse where POS. SYNC OUTPUT is Connected to Scope with a Clip Lead. Notice baseline preceding the Pulse.

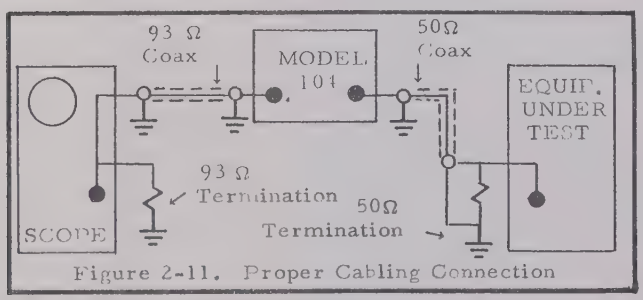


Figure 2-11. Proper Cabling Connection

2.4 SPECIAL APPLICATIONS

2.4.1 Output at Ground: The positive pulse output of the DATAPULSE Model 104 is specified with baseline nominally around ground, or more precisely, at +0.5 volts. Some applications, such as certain diode tests, require a baseline more near ground. The Model 104 can meet this requirement if the output bias is increased or if a dc offset power supply is used. Both methods offer relative advantages; the use of one or the other depends on the particular requirements involved. Both methods are discussed below.

a. Increasing Output Bias: This method of adjusting baseline dc level is easiest because it requires the resetting of only two internal adjustments as follows:

(1) With the polarity switch on POSITIVE, set the 130v power supply to 120v with the +130 Adj.
(2) Set REPETITION RATE control to EXT and observe the dc level at the pulse output jack.
(3) Adjust R107 (POS. BIAS) for the required baseline dc level. Waveshape is usually

good when using this method; however, since the output tubes are not being driven as firmly, due to increased bias, the rise time is increased to approximately 15 nanoseconds and the output amplitude is reduced by approximately 20%. Figure 2-12 shows a Positive Pulse with Baseline +50 Millivolts Off-Ground, accomplished using this method.

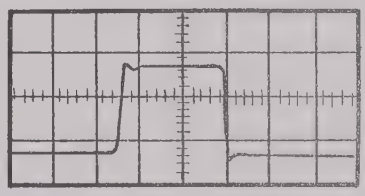


Figure 2-12. Positive Pulse with Baseline at +50mv.

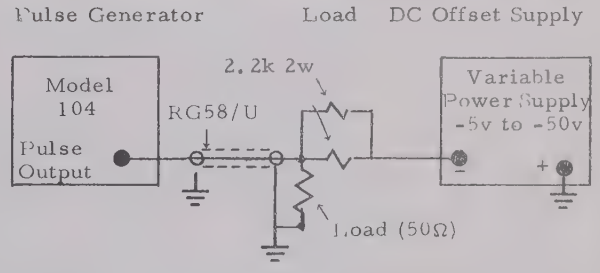


Figure 2-13. Wiring for DC Offset Power Supply

b. DC Offset Voltage:

(1) Connect a dc variable voltage power supply as shown in Figure 2-13
(2) Place the repetition rate control in the EXT. position and observe the dc level at the output jack with the polarity switch on "+".

(3) Adjust the dc offset voltage until the desired baseline dc level is obtained.

Better waveform is obtained with this method, and rise time is not affected because the output is still driven firmly. A third merit of this technique is that the baseline may be placed below ground if desired. The waveform obtained with method is shown in Figure 2-14 A slight variation in amplitude is sustained due to the loading effects of the offset circuit.

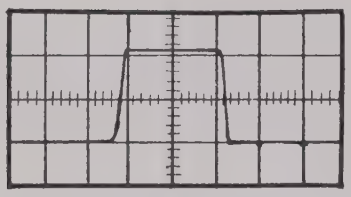


Figure 2-14. Positive Pulse with Baseline at +1 mv.

2.4.2 Positive Sync Pulse Output Polarity Inversion: Some applications require negative polarity sync pulses which are not normally available in the Model 104. DATAPULSE Model 2101 Trigger Pulse Inverting Transformer, available as an accessory was designed to permit inversion of any of the instrument's three sync pulses.

2.4.3 Negative Pulse External Triggering: DATAPULSE Model 2101 Trigger Pulse Inverting Transformer, discussed above, may also be used to invert negative trigger pulses which may then be applied to the POS. EXTERNAL TRIGGER INPUT of the Model 104.

3.1 BLOCK DIAGRAM DESCRIPTION

W numbers referenced below correspond to the waveforms shown on the Block Diagram and Fig. 3-1.

V numbers correspond to tube numbers on the schematic drawings in Section IV.

The pulse repetition rate is generated by the "Free Running Multivibrator". (When the REP. RATE switch is on EXT this circuit operates as a Schmidt trigger.) In either case its square wave output (W1) is differentiated and the positive going portion is amplified in the "Sync Trigger Amplifiers" to produce fast narrow triggers (W2). A signal which is essentially (W2) may be used to synchronize the "Divided Sync Blocking Oscillator".

(W2) is buffered in the "Sync Cathode Follower" and is offered as the POSITIVE SYNC OUTPUT. These triggers (W2) also drive the delay circuitry. If the PULSE DELAY control is on the 0.5 MICROSEC step, this signal is fed down a variable delay line producing a delay trigger (W4). If the PULSE DELAY control is on any of the 1.0 MICROSEC through 10 MILLISEC steps this signal triggers the "Delay One Shot Multivibrator" whose output is a negative gate (W3).

The transistors Q_1 and Q_2 are inverters which shape the signal (W5) whether it arrives via the "0 -- .5 μs Delay --Variable Delay Line" or as the positive going portion of the differentiated negative gate. This signal (W5) passes through four stages of amplification.

The output of the next amplifier stage (V10) - (W7) is used to trigger the pulse width circuitry. If the PULSE WIDTH control is set at 0.5 MICROSEC the trigger is sent down the "0 -- .5 μs Width -- Variable Delay Line" where output is a delayed trigger (W9). If it is set at 1.0 MICROSEC through 0.5 MILLISEC the trigger activates the "Width One Shot Multivibrator" whose output is a negative gate (W8).

The transistors in the "Trailing Edge Trigger Amplifiers" then shape the signal whether it be the positive trigger from the "0 -- .5 μs Width -- Variable Delay Line" or the positive going portion of the differentiated negative gate.

Applying the leading edge trigger (W6), the trailing edge trigger (W11) and the negative gate (W12) to the "Pulse Forming Circuits" a high amplitude fast rise and fall time pulse is produced (W13). This signal is then condenser-coupled to the "Output Amplifier" where it is transformed into a heavy current pulse. It may then be applied to the "Attenuator" and reduced to the desired power level.

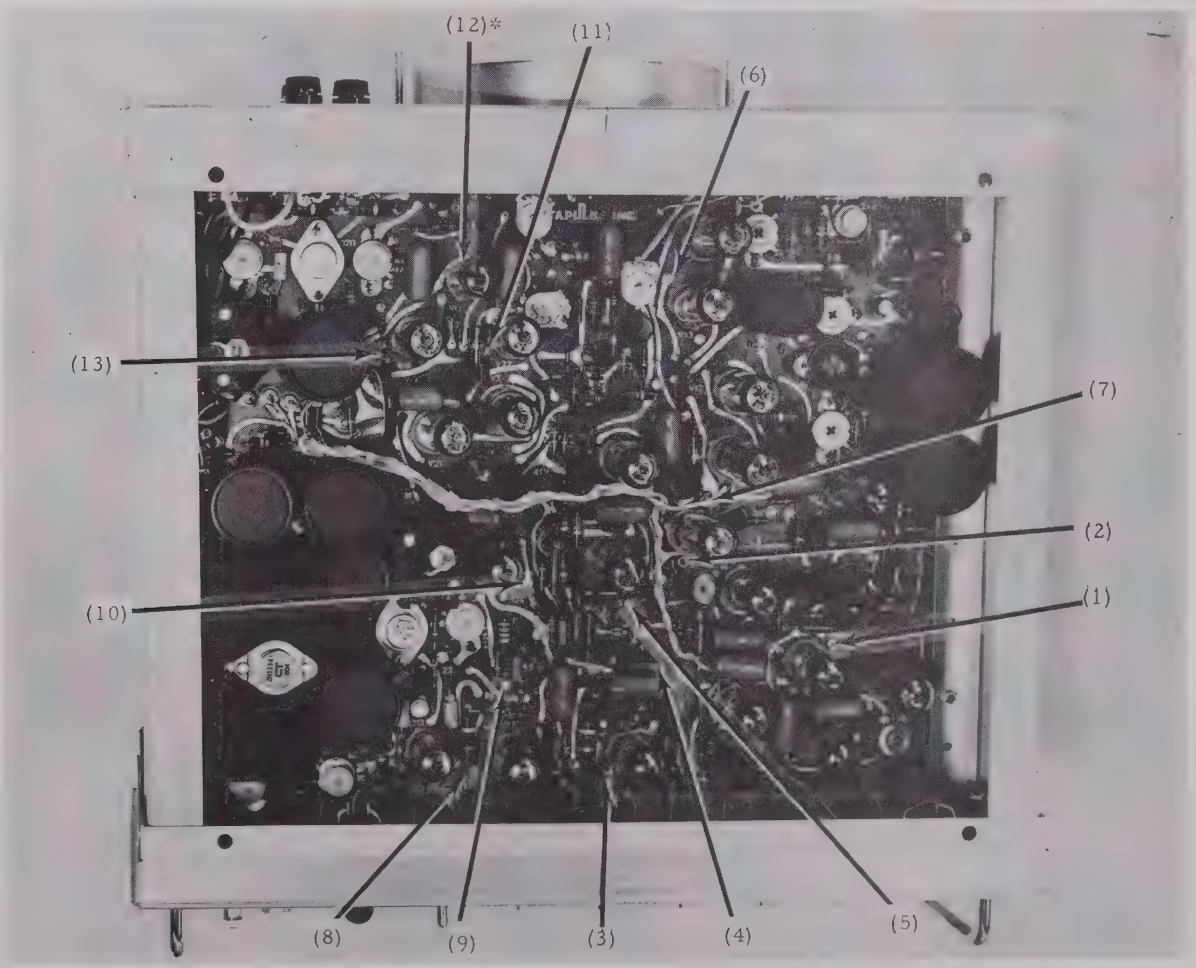
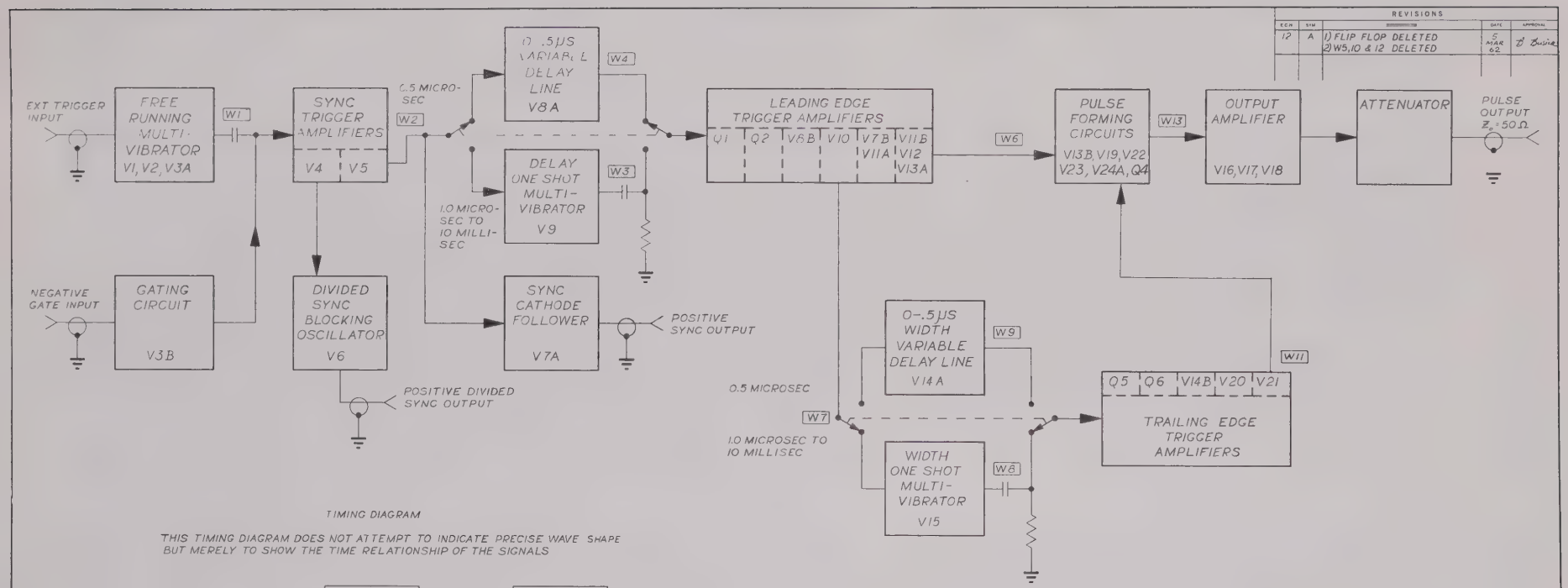


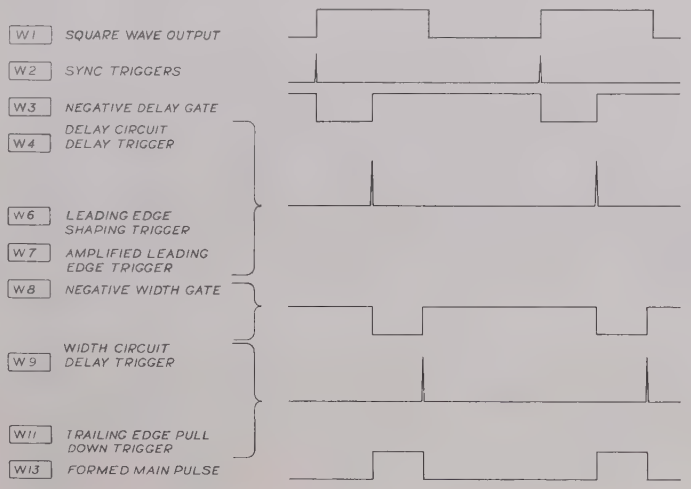
Figure 3-1. Signal Test Points

* Test Point (12) is tube socket pin 1 on opposite side of board.



TIMING DIAGRAM

THIS TIMING DIAGRAM DOES NOT ATTEMPT TO INDICATE PRECISE WAVE SHAPE BUT MERELY TO SHOW THE TIME RELATIONSHIP OF THE SIGNALS


W1 SQUARE WAVE OUTPUT
W2 SYNC TRIGGERS
W3 NEGATIVE DELAY GATE
W4 DELAY CIRCUIT DELAY TRIGGER
W6 LEADING EDGE SHAPING TRIGGER
W7 AMPLIFIED LEADING EDGE TRIGGER
W8 NEGATIVE WIDTH GATE
W9 WIDTH CIRCUIT DELAY TRIGGER
W11 TRAILING EDGE PULL DOWN TRIGGER
W13 FORMED MAIN PULSE

REVISIONS

ECN	SYM		DATE	APPROVAL
12	A	1) FLIP FLOP DELETED 2) W5, 10 & 12 DELETED	2 MAR 62	B Burns

LIST OF MATERIALS

REQD	PART NO.	DESCRIPTION	ITEM

UNLESS OTHERWISE SPECIFIED: DIMENSIONS ARE IN INCHES; TOLERANCES ON: 2 PLACE DEC. ±, 3 PLACE DEC. ±, ANGLES ±; MATERIAL; FINISH; DO NOT SCALE DWG.

DRAWN GRANADOS 5 Jan 62
CHECKED B BURNS Bburns
APPROVED R J 2.1 .2
APPROVED M Mercurio 6 Feb 62
APPROVED
RELEASED B Burns 3 MAR 62

TITLE: BLOCK DIAGRAM 10 MEGACYCLE PULSE GENERATOR

MODEL - 104

SCALE NONE

DATAPULSE, INC. INGLEWOOD CALIFORNIA

DWG SIZE D 41000-003

SHEET 1 OF 1

NEXT ASSY	USED ON	NEXT ASSY	FINAL ASSY
APPLICATION		QTY REQD	

41000-003 A

3.2 THE ASTABLE MULTIVIBRATOR

Just as the conventional plate coupled multivibrator may be considered as two condenser coupled amplifiers, this circuit may be considered as two condenser coupled cascode amplifiers.

Since the coupling is entirely capacitive, neither tube can remain permanently cut off. The circuit has then no stable states but has instead two quasi-stable states between which the circuit will make periodic transitions.

Assume the left side V1B is conducting. Its plate is bottomed and its grid is a cathode potential. V2B is cut off and its grid is moving positive as the condenser C1 charges toward B++ through R1. When the grid of V2 reaches "cut on" potential V2 starts conducting heavily. Its plate drops rapidly coupling a negative step to the grid of V1B through the condenser C2. This cuts off V1. The potential at the grid of V1 now starts going positive as C2 charges toward B++ through R2 and so the reverse transition occurs.

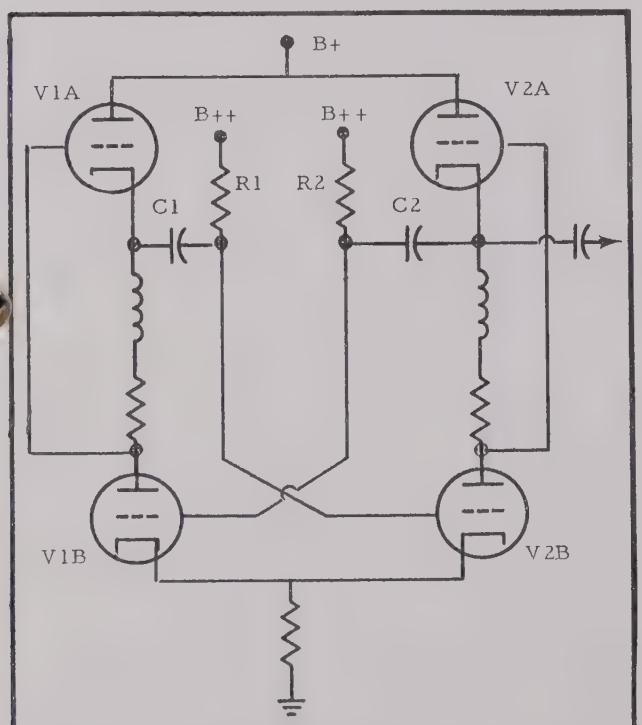


Figure 3-2. The Astable Multivibrator

3.3 THE ONE-SHOT MULTIVIBRATOR

The pulse delay circuitry is a cathode coupled one shot multivibrator. Since pulse width generation is essentially a delay function, (i.e., the delay of trailing edge with respect to leading edge) the same technique is used to perform both operations. For this reason only delay shall be discussed.

In the quiescent state, V9B is cut off because of the bias imposed upon its grid (pin 7) by the voltage divider composed of R37, R38, R40 and R43. V9A is conducting because of its positive grid return through Rt. As the plate load R37 is great (47K) with respect to Rk, the common cathodes of V9A and V9B are at a potential around ground. At time (t0) a positive input trigger causes V9B to conduct and because of the low impedance (470 Ω) in the plate of V9B (pin 6) a large current flows through Rk causing the cathode of V9A (pin 3) to become sufficiently positive to cut off V9A. As the plate (pin 1) of V9A becomes more positive, because of decreased in current flow, this waveform is coupled across C16-R38 and C18-R40 to the grid of V9B causing more current to flow, regeneratively saturating V9B. As soon as the cathode of V9A (pin 3) becomes more positive than its grid (pin 2) Ct begins to charge through Rt. This charge continues until a point is reached at time (t2) when the grid of V9A (pin 2) is sufficiently positive to allow V9B to again conduct driving its plate (pin 1) negative. This negative waveform coupled across C9-R38 and C18-R40 to the grid of V9B (pin 7) causes conduction of V9B to decrease, forcing the cathode of V9A less positive and increasing conduction, regeneratively saturating V9A and cutting off V9B. The cathodes of V9A and V9B return to their quiescent state and the grid of V9A follows the cathodes down as grid current discharges Ct completing the cycle.

The trailing edge of the negative gate at the plate of V9B (pin 6) is differentiated and is shaped by transistor inverters.

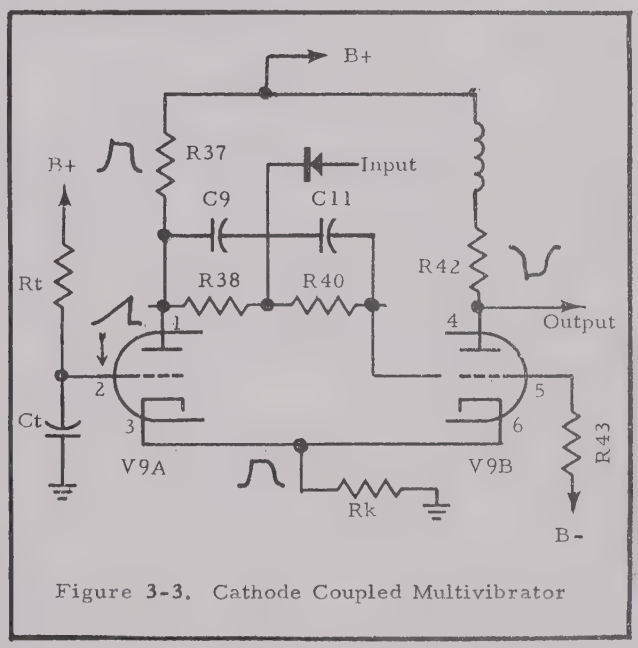


Figure 3-3. Cathode Coupled Multivibrator

3.4 TRANSFORMER COUPLED AMPLIFIER

Initially, the tube is cut off because of bias return. As a positive pulse is applied to the grid, the plate conducts heavily and goes negative. The polarity of the transformer is such that a negative charge upon the plate provides a positive going signal to the grid of the next tube. Rp is used to damp the secondary of the transformer to prevent oscillations. Pulse narrowing takes place (see Figure 3-5) because each preceding tube only conducts when the pulse is above the cutoff point; thus, the time from the base line to approx. the 85% amplitude point is eliminated.

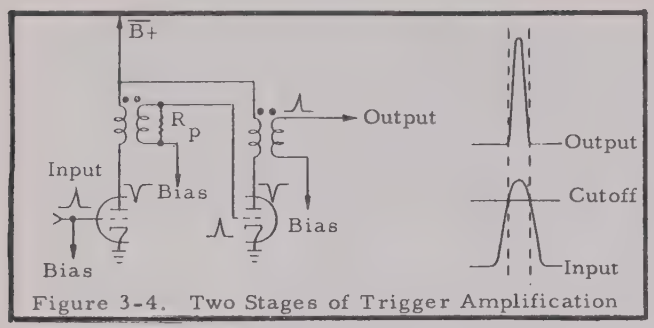


Figure 3-4. Two Stages of Trigger Amplification

3.5 PULSE FORMING CIRCUITS

V19 is normally conducting. Its plate (pin 5) sets slightly above ground. The negative duration gate applied at V19 (pin 1) cuts off V19 and its plate starts to rise at a rate governed by circuit capacity. A few nanoseconds later the leading edge trigger is applied to the "lift up diode" (V13B, V14A) whose low impedance charges the capacitor rapidly causing a fast rise leading edge. The top of the pulse remains at the voltage set by the top slope control because V19 is held off by the duration gate for the duration of the pulse. The fase rise pulse is applied to the grid (pin 2 and 7) of the cathode follower (V23), whose output drives the output amplifier section. At the end of pulse time, the gate at the grid of V19 subsides and V19 begins to conduct. Simultaneously, the positive trailing edge trigger is applied to the grids (pin 2 & 7) of the trailing edge pull-down tube (V22) driving its plate sharply negative, thus discharging circuit capacity and creating a fast fall trailing edge. This fast rise and fall positive pulse is then applied to the output amplifier section. The capacitors C42 (overshoot) and C59, C60 provide a feedback network to trim pulse irregularities.

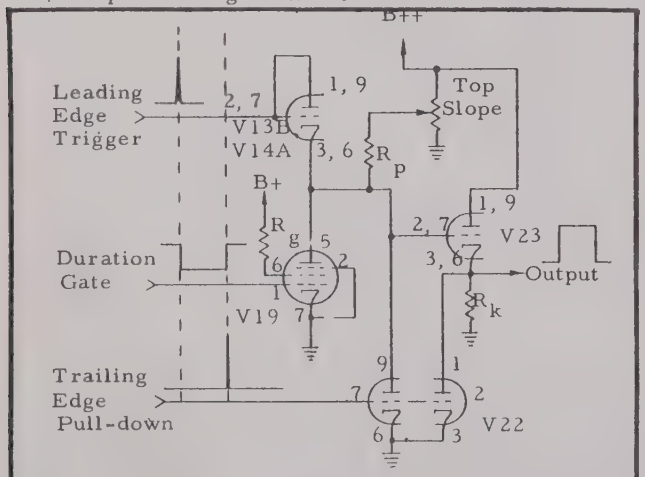


Figure 3-5. Simplified Pulse Forming Circuits

3.6 OUTPUT AMPLIFIER

The fast rise and fall pulse from V23 is coupled across C77 to the rise time control R64. Since no commutation is provided, an increase in the resistance of R64 will cause rise time to be increased in an exponential manner because of the input capacity of the output tubes V17 and V18. The screen is "boot strap" connected to the cathode; therefore, the screen to cathode voltage and screen to control grid voltage remain relatively constant. This increases gm which allows a greater degree of wave shape preservation from input to output.

Positive output pulses are obtained from cathode followers with baseline around ground potential. As polarity is changed to negative, the output tube configuration is changed to operate the output tubes as amplifiers, with output taken at the plate. In addition, the ground reference for the power supply is switched such that the baseline remains around ground.

Bias is provided through a cathode follower whose low impedance discharges C77 thus preventing a bias shift with changes in duty cycle.

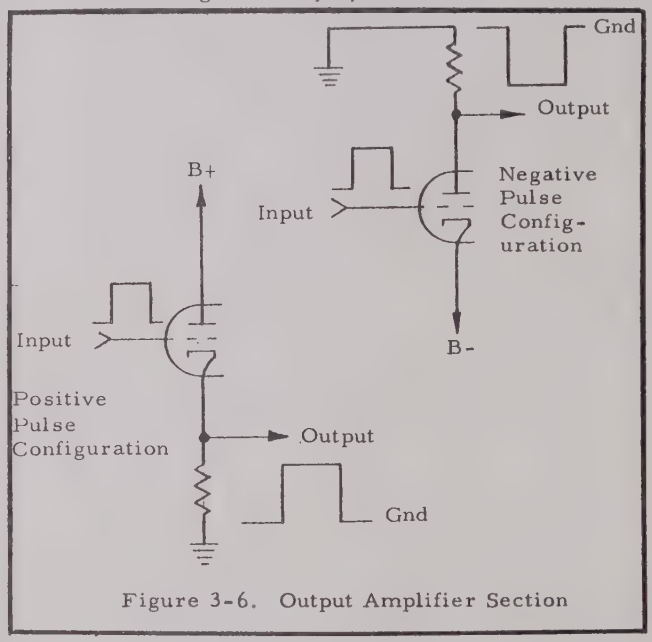


Figure 3-6. Output Amplifier Section

3.7 THE +100 REGULATOR

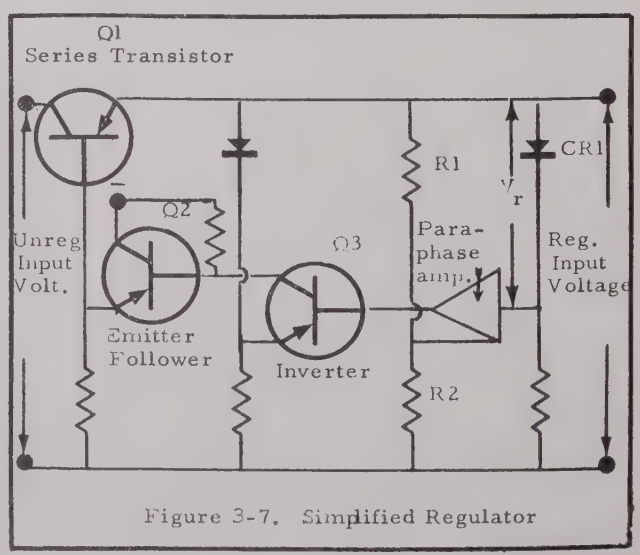


Figure 3-7. Simplified Regulator

Changes in output voltage are sensed by the voltage divider network R1-R2 and compared in the paraphase amplifier against the voltage reference V_r. This "error" signal is amplified by the inverter Q3 which drives the emitter follower Q2. The emitter follower controls the series transistor which absorbs voltage fluctuations.

Assume the output voltage starts to increase due to either increased line voltage or decreased load. The paraphase amplifier amplifies this change, increasing the base emitter voltage of the inverter causing it to conduct harder. The increased current in the inverter causes an increase in the emitter follower current which biases Q1 more positive causing it to conduct less;consequently drop more voltage to offset the voltage increase at the output terminals.

3.8 THE +225 AND +130 REGULATORS

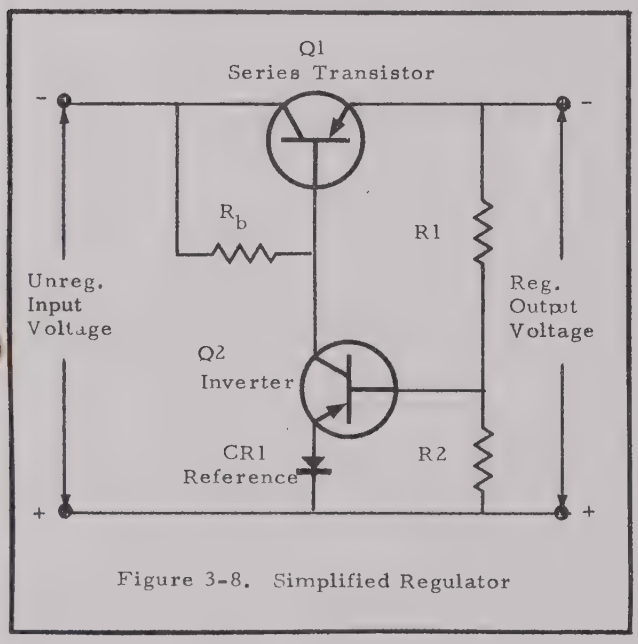


Figure 3-8. Simplified Regulator

The series transistor Q1 absorbs voltage changes due to load or line variations. The bias of Q1 is set by the control current flowing through the base resistor R_b. This control current is governed by the base emitter voltage and transconductance of the inverter-transistor Q2. The voltage established by R1-R2, minus the reference voltage set by CR1, is the base emitter voltage of Q2.

Assume a voltage increase at the output terminals. The base of Q2 then goes negative with respect to its emitter which is held fast by the zener. The negative going base of Q2 causes it to conduct harder driving the base of Q1 positive, decreasing the current flowing in the series transistor such that more voltage is dropped across Q1 to offset the voltage increase at the output terminals.

3.9 THE POWER SUPPLY PROTECTION CIRCUITRY

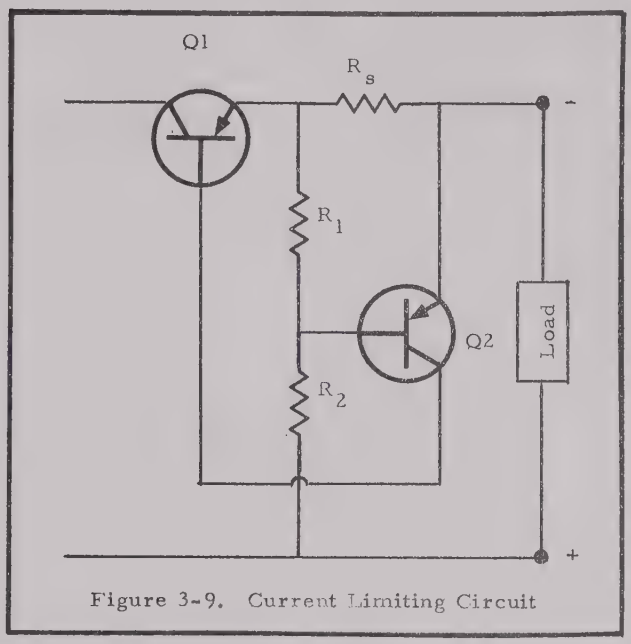


Figure 3-9. Current Limiting Circuit

Each transistor voltage regulator utilizes a current limiting circuit similar to the one shown in Figure 3-9. When normal currents flow in the load Q2, the protection transistor, is biased off by the voltage divider R1-R2. Should load current become in ordinate, enough voltage is developed across the current sensing resistor R_s to bias Q2 into conduction. The harder Q2 conducts the lower the base to emitter voltage at the series transistor Q1. The lower the base to emitter voltage of Q1 becomes, the less it conducts. Thus current limiting is effected.

An overload condition is no longer commensurate with voltage regulation. The output voltages drop sharply under overload.

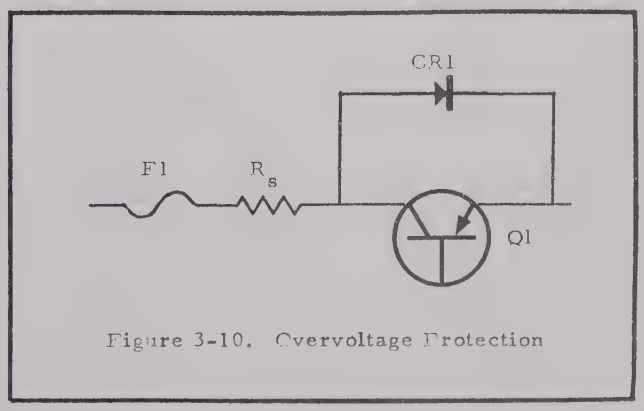


Figure 3-10. Overvoltage Protection

Under short circuit conditions, the series transistor (which under normal conditions must absorb voltage fluctuations due to line and load variation) is also exposed to a voltage drop equal in magnitude to the regulator output voltage. Due to the avalanche and punchthrough foibles of transistors, overvoltage protection is provided for the series transistors. In the +100 regulator enough series transistors are stacked to stay within voltage rating under all conditions. In the +225 and +130 regulators the series transistors are protected against overvoltage by zener diodes. Thus under light overloads the only effect is a drop in output voltage. Under moderate overloads the output voltage drops and the zener conducts. The fuse will blow eventually. Under short circuit conditions the fuse blows immediately; the zener carries the short circuit surge current until the fuse acts.

3.10 THE DIVIDED SYNC BLOCKING OSCILLATOR

We will first consider the operation of the blocking oscillator without the application of the sync pulses. Consider that there is initially a negative charge on C adequate for biasing the tube V1B beyond cutoff. The capacitor C discharges through R1, R2 toward B+. When the grid voltage reaches cut-on the tube starts to draw plate current and the plate voltage drops. The drop in plate voltage causes an increase in grid voltage which in turn results in a further decrease in plate voltage. The regenerative action continues until limited by the non-linearity of the tube. At the pulse peak grid current causes the grid to go negative resulting in an increase in plate voltage, the plate current diminishes, and the grid voltage undershoots going considerably below cutoff.

Now let us inject a synchronizing signal by means of the cathode follower V1A. Without this signal the next firing of the blocking oscillator would occur

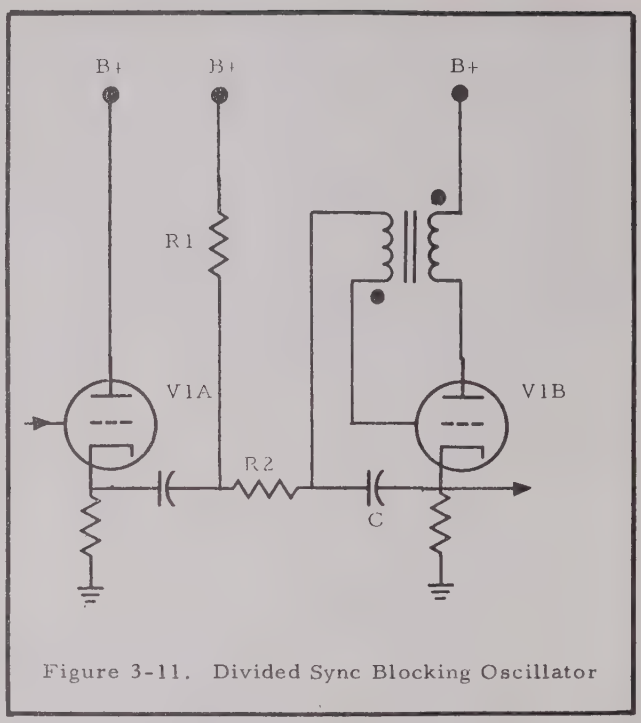


Figure 3-11. Divided Sync Blocking Oscillator

when the grid voltage reached cut-on as determined by the discharge of C. However, this discharge "ramp" now has superimposed on it the synchronizing pulses which cause the grid potential to reach cut on at sync time. The oscillator fires, therefore, at a time dictated by the occurrence of a pulse and is not permitted to terminate its cycle naturally.

MAINTENANCE INSTRUCTIONS

4.1 PREVENTIVE MAINTENANCE

4.1.1 Preventive Inspection and Service: Regular inspection and service of a preventive nature will result in optimum performance and longer life of this instrument. Dust covers should be removed at regularly scheduled intervals to permit inspection for dust, tarnish, corrosion, loose nuts and bolts (especially those serving as electrical conductors), loose cables and fuses, charred insulation, scorched resistors and broken wiring. Discoloration of the printed circuit board, due to heat, does not affect the board's electrical properties and may be disregarded in most cases. This problem may be alleviated if the air filters are cleaned frequently and thoroughly as described below.

4.1.2 Filter Cleaning: The instrument is cooled by air drawn into the interior through a washable aluminum-mesh, adhesive coated filter. When dirty, the filter will restrict the flow of cooling air and cause overheating. To clean the filter, first rap it gently on a hard surface to remove loose dirt. Then wash the filter with hot water and soap. DO NOT USE CAUSTICS. After rinsing and drying, dip or spray the filter with an approved adhesive, such as FILTER-COAT manufactured by the Research Products Corporation of Madison, Wisconsin.

4.1.3 Fan Motor Lubrication: The fan motor should be lubricated at regular intervals with a few drops of light machine oil.

4.1.4 Minor Repairs: The operator should be thoroughly acquainted with the instrument's circuit theory and component location before attempting repair. In all cases, setting and adjustment of controls should be checked in order to verify that difficulties encountered are actually caused by malfunction and not by operation outside of specifications. Check tubes and transistors in suspected circuits prior to conducting extensive tests on other components. A check of the important waveforms brought out to the front panel will be of great assistance.

4.1.5 Recalibration: This instrument was designed to provide maximum reliability and stability. To insure that accuracy remains within stated limits, we suggest that calibration be checked after every 200 hours of operation. If the unit is used intermittently, calibration should be checked every three months. Complete instructions for calibration are given in this manual.

4.2 PARTS REMOVAL AND REPLACEMENT

4.2.1 General: This instrument is sturdily built and easily accessible. Removal of most parts is so simple that explanations are unnecessary. However, some parts are more easily removed if a definite procedure is followed. Replacement of some parts will also require partial recalibration. Refer to Section 4.4 of this manual for calibration instructions.

4.2.2 Removal of Dust Covers: The dust covers are held in place by small screw-head fasteners. To remove, turn the fasteners a quarter turn counterclockwise with a common screwdriver. To remove the top dust cover: (1) loosen the four fasteners in the sides of the bottom dust cover; (2) remove the four fasteners on the sides of the top dust cover; (3) loosen the two fasteners on the top of the top dust cover; and (4) lift the cover up and off.

To remove the bottom dust cover: (1) turn the instrument upside down; (2) remove the four fasteners on the sides of the bottom cover; (3) loosen the four fasteners on the bottom of the cover; and (4) lift the cover up and off.

4.2.3 Replacement of Power Transistors: The power transistors and zener diodes which are mounted to heat sinks must have a thin film of silicone grease (such as Dow-Corning DC-4) applied to their common contact surfaces. In replacing the stud mounted zener diodes, care must be used not to exceed 12 in-lbs torque in tightening the mounting nut.

To replace transistors located on the large heat sink assembly: (1) remove the eight screws on the bottom of the assembly which secure the epoxy tie bar; (2) remove the three screws that secure the appropriate heat sink to the hinge plate; (3) rotate the heat sink to an accessible position using the cable as an axis; and (4) proceed in the obvious manner.

4.2.4 Replacement of Switches: The output amplifier switches may be ordered from DATAPULSE as single sections or as unwired assemblies. If a single wafer on the oscillator, delay, or width switch is defective, the entire switch must be replaced. These are available from our factory either wired or unwired.

The capacitors mounted to these switches are matched sets. Should a capacitor require replacing, its entire set (as indicated on the schematic) must be replaced with a new matched set. These matched condenser sets are available from DATAPULSE. Recalibration is required if the switches or the condenser are replaced.

4.2.5 Replacing Tubes: Tubes should not be replaced unless they are actually causing trouble. Unnecessary replacement only necessitates recalibration. Tubes removed for maintenance reasons should be returned to the socket from which they were removed unless found to be defective. When replacement is necessary, only high quality tubes should be used.

4.2.7 Soldering Considerations: Although printed wiring is quite vulnerable to heat excesses, a great deal of resoldering can be done on a single joint if care is taken. A 35 watt wedge tip or pointed tip iron and 60-40 rosin core solder are quite effective. Where both sides of the board are accessible apply the tip of the iron (on the side opposite the component) directly to the solder fillet and pull gently on the pigtail with pliers from the opposite side. Where both sides of the circuit board are not accessible, the component lead will be fed through the board through an eyelet. Apply the iron tip to the eyelet and pull the pigtail out with the pliers. To insert a new component, clean out the hole with a sharp object (it may be necessary to apply more heat) and insert the new component, soldering in the old place.

4.3 TROUBLESHOOTING PROCEDURE

Before any troubleshooting is attempted the front panel controls should be checked for proper setting. You may wish to refer to "Operating Considerations" section which details many of the limitations of the instrument and describes the performance to be expected. After you have ascertained that a trouble does exist, you may continue according to the procedures outlined in this section. See Figure 4-2.

Many apparent malfunctions are due to improper calibration of one or more of the circuits, and often a tube is replaced that requires recalibration. If you suspect that a circuit is miscalibrated refer to section 4.5 of this manual which describes a procedure for determining calibration status. Section 4.4 provides a detailed calibration procedure.

Whenever trouble occurs check the power supply voltages. This test may be done by following paragraph 4.4.2.1 of the "Calibration Procedure". It may be assumed that the power supplies are functioning properly if the output and ripple voltages are correct.

When malfunction can be attributed to a particular circuit, perform a complete visual inspection in that area. See Figure 4-1 for the location of circuits. Frequently visual inspection reveals the effects of the trouble (such as burned resistors) rather than the cause. However, these effects may give clues as to the actual cause. Care should be taken to find the real cause.

Most instrument failures will be due to tube failure. If visual inspection fails to reveal the cause of trouble, replace pertinent tube or tubes by substitution. Do not rely on tube testers to indicate whether a tube is "good" or "bad". If a tube works in a circuit it is good. Be sure to return good tubes to their original sockets.

4.3.1 Troubleshooting the Power Supplies: Almost all power supply failure may be typified by collector to emitter shorts (transistors) and anode to cathode shorts (rectifiers and zener diodes). These conditions are easily detected "in circuit" with an ohmeter because they measure zero resistance in both directions. In the +225v and +130v supplies a short in any of these devices (other than the protection transistor) will be made evident by a blown fuse. A shorted protection transistor will cause the regulator to apparently regulate under light loads, but will cause the output voltage to drop under even moderate loads.

The +225v supply is in fact a +125v regulator stacked on top of the +100v regulator. In troubleshooting the +225v supply make certain the +100v is operating correctly.

The inverter in the +100 supply utilizes -10v for its collector return. Be certain the -10v supply is in order before troubleshooting the +100 regulator.

The -18v output voltage will drop below tolerance if it or the -10v supply suffers an overload. The removal of Q2 or Q6 or V201 with the power on, or a short at Q1 or Q5 will remove the bias from V8B or V14B and overload the -4.5v supply. The effect is that of the trigger amplifiers taking off and free-running.

The absence of all supply voltage with the pilot lamp out and the fan running are symptoms of over heating. The thermal cut out has removed the 115vac line power to protect the temperature sensitive components and power will be restored when temperature reaches a safe level. This is an abnormal condition indicating a dirty air filter or an obstructed air intake.

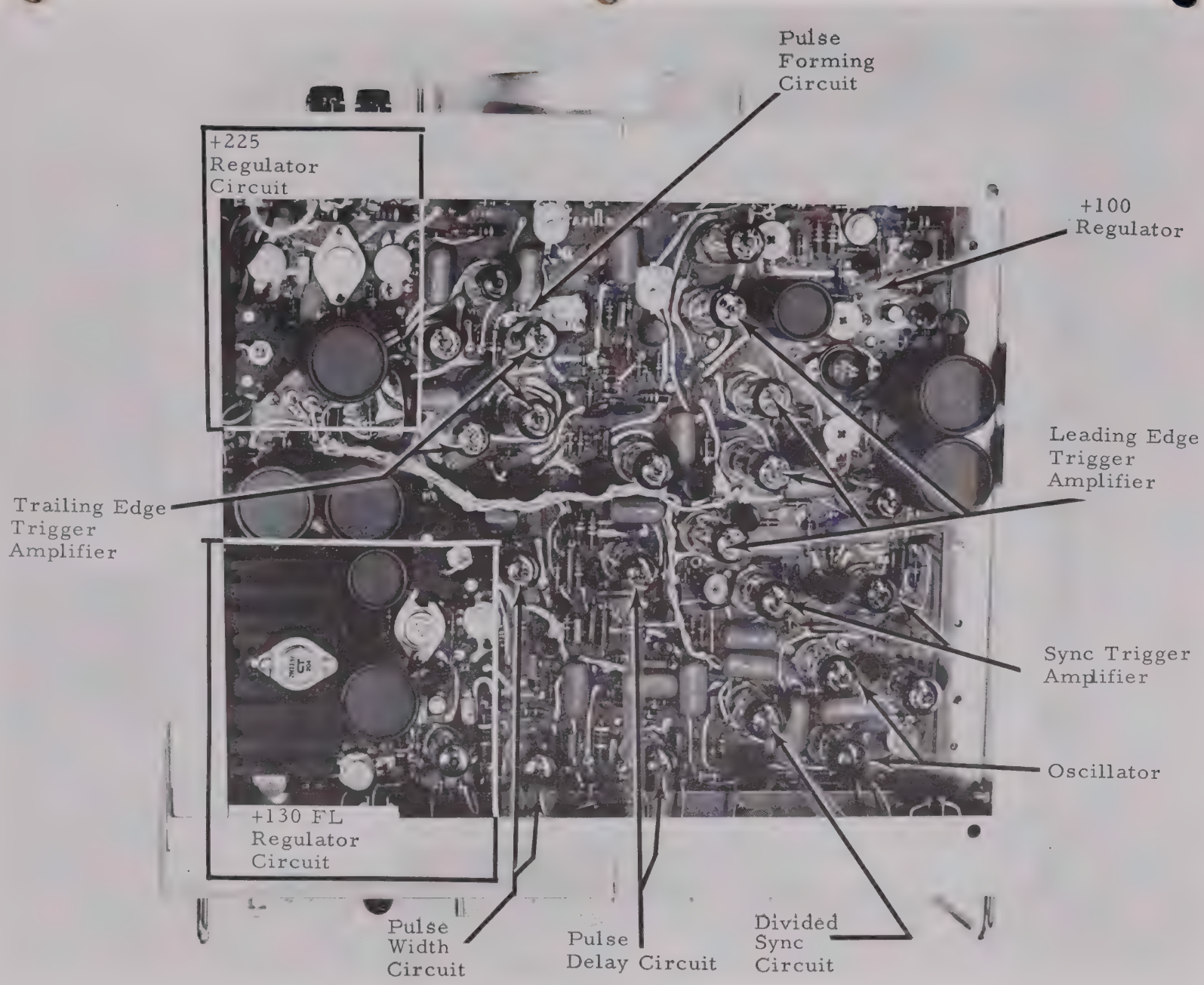


Figure 4-1. Circuit Loacations

TABLE I
TUBE VOLTAGE AND RESISTANCE

Measurements were taken under the following conditions:

All measurements are with respect to ground

Resistance measurements in parentheses indicate positive meter terminal connected to ground.

All voltages are dc.

Voltage measurements are at 115v ac line.

Measurements were made with Simpson Model 260 (20,000 ohms per volt).

Repetition rate control was on EXT.

Pulse Delay control was on 0.5 microsec.

Pulse Width control was on 0.5 microsec.

Gated-Not Gated Switch was on Not Gated.

Both attenuation controls were on "0".

Polarity switch was on "+".

The voltages and resistances tabulated here are typical values. On some instruments the readings will differ considerably from this tabulation due to manufacturing tolerances and variations in component characteristics. These tables should be used in conjunction with careful study of the schematic diagrams and the "Theory of Operation" section of this manual.

	VOLTAGE PIN NUMBER									RESISTANCE PIN NUMBER								
TUBE	1	2	3	4	5	6	7	8	9	1	2	3	4	5	6	7	8	9
V1: 6DJ8	+100	+38	+39	0	6.3v ac	+38	+6	+6	0	1.7k 600Ω	14k (280k)	14k (280k)	22Ω	22Ω	14k (280k)	1.5M	470Ω	0
V2: 6DJ8	+100	+52	+53	6.3v ac	0	+52	+.75	+6	0	1.7k 600Ω	12k ∞	12k ∞	22Ω	22Ω	12k ∞	65k (240k)	470Ω	0
V3: 6DJ8	+100	+50	+50	0	6.3v ac	+100	-2.4	-2.5	0	1.7k (600Ω)	30k	4.2k	22Ω	22Ω	1.7k (600Ω)	10k	11k	0
V4: 6688	0	-2.4	0	6.3v ac	0	X	+100	0	+100	0	4k	0	22Ω	22Ω	X	1.7k (600Ω)	0	1.7k (600Ω)
V5: 6DJ8	+100	-4.3	0	0	6.3v ac	+100	-4.3	0	0	1.7k (600Ω)	400Ω	0	22Ω	22Ω	1.7k (600Ω)	400Ω	0	0
V6: 6DJ8 ①	+100	-4.3	+.25	6.3v ac	0	+100	-.45	+.2	0	2k (1k)	400Ω	330Ω	22Ω	22Ω	2k (1k)	80k	330Ω	0
V7: 7119	+100	-10	0	6.3v ac	6.3v ac	+.85	-4.3	0	+100	1.7k (600Ω)	14Ω (100Ω)	0	22Ω	22Ω	520Ω	400Ω	22Ω	1.7k (600Ω)
V8: 6DJ8	+100	-4.3	0	0	6.3v ac	+100	-10	-4.3	0	1.7k (600Ω)	400Ω	100Ω	22Ω	22Ω	1.7k (600Ω)	500Ω	400Ω	0
V10: 6DJ8	+100	-10	0	0	6.3v ac	+100	-10	0	0	1.7k (600Ω)	14Ω (100Ω)	0	22Ω	22Ω	1.7k (600Ω)	14Ω (100Ω)	0	0
V9: 6DJ8 ②	+4.4	+.8	+.45	6.3v ac	0	+100	-4.4	+.45	0	38k (20k)	300k	190Ω	22Ω	22Ω	2.2k 1.2k	60k 18k	190Ω	0
V11: 7119	+225	-18.5	0	6.3v ac	6.3v ac	0	-10	0	+100	5.5k 1.6k	200Ω (300Ω)	0	22Ω	22Ω	0	14Ω (100Ω)	22Ω	1.7k (600Ω)
V24: 7119	0	0	+.8	0	0	X	X	6.3v ac	X	0	0	140k	22Ω	22Ω	X	X	22Ω	X
V12: 7119	+225	-18.5	0	0	0	0	-18.5	6.3v ac	+225	5.5k (1.6k)	200Ω (300Ω)	0	22Ω	22Ω	0	200Ω (300Ω)	22Ω	5.5k (1.6k)
V13: 7119	+225	-18.5	0	0	0	+.8	0	6.3v ac	0	5.5k (1.6k)	200Ω (300Ω)	0	22Ω	22Ω	140k	0	22Ω	0
V14: 6DJ8	+100	-4.3k	0	6.3v ac	0	+100	-10	-4.3	0	1.7k (600Ω)		100Ω	22Ω	22Ω	1.7k (600Ω)	500Ω	400Ω	0
V15: 6DJ8	+4.4	+.8	+.45	0	6.3v ac	+100	-4.4	+.45	0	38k (20k)	300k	190Ω	22Ω	22Ω	2.2k (1.2k)	60k (18k)	190Ω	0
V16: 12BH7	0	-40	-40	3.15 v ac	3.15 v ac	+130	+130	+130	3.15 v ac	0	300k	150k	0	0	500k	500k	∞	0
V17: 6DQ5	-40	3.15v ac	0	+130	-40	0	3.15v ac	+130	+130	150k	0	50Ω	∞	150k	50Ω	0	∞	500k
V18: 6DQ5	-40	3.15v ac	0	+130	-40	0	3.15v	+130	+130	150k	0	50Ω	∞	150k	50Ω	0	∞	500k
V19: 6AU6	-.3	0	6.3v ac	0	+80	+100	0	X	X	3.8k	0	22Ω	22Ω	140k	1.7k (600Ω)	0	X	X
V20: 6DJ8	+100	-10	0	0	6.3v ac	+100	-10	0	0	1.7k (600Ω)	14Ω (100Ω)	0	22Ω	22Ω	1.7k (600Ω)	14Ω (100Ω)	0	0
V21: 7119	+100	-10	0	6.3v ac	6.3v ac	0	-10	0	+100	1.7k (600Ω)	14Ω (100Ω)	0	22Ω	22Ω	0	14Ω (100Ω)	22Ω	67k (600Ω)
V22: 7119	+13	-18.5	0	0	0	0	-18.5	6.3v ac	+.80	10k	200Ω (300Ω)	0	22Ω	22Ω	0	200Ω (300Ω)	22Ω	140k
V23: 7119	+225	+.8	+13	6.3v ac	6.3v ac	+13	+.8	0	+225	5.5k (1.6k)	140k	10k	22Ω	22Ω	10k	140k	22Ω	5.5k (1.6k)
V201: OB2	0	-108	X	-108	0	X	-108			0	3k (14k)	X	3k (14k)	0	X	3k (14k)		
V202: OB2	0	-108	X	-108		X	-108			0	6k	X	6k (200k)	0	X	6k		

① Measurement taken with DIVISION ADJUST control not on OFF.

② Measurement taken with PULSE DELAY control on 1.0 microsec.

TABLE II
TRANSISTOR VOLTAGE AND RESISTANCE

See Table I for control settings and other notes.

TRANSISTOR	VOLTAGE (Volts)			RESISTANCE (Ohms)		
	EMITTER	BASE	COLLECTOR	EMITTER	BASE	COLLECTOR
Q1: 2N2048	0	-.4	-.1	0	+14	650
Q2: 2N2048	0	+1.5	-9.6	0	4k (15)	650
Q3: T6027	0	+1.6	-4.6	0	4k (20)	700
Q4: T6027	0	-.35	-.15	0	4k (35)	700
Q5: 2N2048	0	-.35	+.1	0	2.4k (15)	450
Q6: 2N2048	0	+1.4	+9.6	0	4k (15)	650
Q201: 2N1136A	-48	-48	-75	65 (120)	950 (50)	240 (55)
Q202: 2N1136A	-23	-23	-48	14 (45)	550 (40)	65 (120)
Q203: 2N1136A	-0.2	+0.11	-23	2 (2)	16 (5)	14 (45)
Q204: 2N1183	-0.11	-0.1	-9.8	16 (5)	30 (17)	15 (60)
Q205: 2N404	0	+92	-0.01	0	300 (8)	30 (17)
Q206: 2N404	+5.9	+6.1	+0.01	180 (900)	300 (900)	150 (230)
Q207: 2N404	+9.3	+9.2	+6.1	300 (15k)	500 (350)	300 (400)
Q208: 2N404	+9.3	+9.2	0	300 (15k)	90k (150)	0
Q209: 2N1136B ③	(-.1)	(-.2)	(-48)	5.6	50 (8)	17 (70)
Q210: 2N404 ③	0	+2.0	-.2	0	400 (10)	50 (8)
Q211: 2N1136A ③	+15	+15	-.2	140 (2k)	750 (130)	50 (8)
Q212: 2N1136B	-0.1	-.2	-48	5.6	50 (8)	17 (70)
Q213: 2N1311	0	+1.25	0	0	200 (10)	5k, 80
Q214: 2N404	0	+2.0	-.2	0	400 (10)	50 (8)
Q215: 2N1136A	+15	+15	-.2	140 (2k)	750 (130)	50 (8)
Q216: 2N1540	9.6	9.8	-18.5	14 (100)	350 (200)	200 (300)

TABLE III
POWER TRANSFORMER VOLTAGE

FROM		TO		
WIRE NO.	COLOR	WIRE NO.	COLOR	VOLTS (AC)
1	red	2	red-yel	122
3	red	2	red-yel	122
4	orn	5	orn-wht	130
6	orn	5	orn-wht	130
7	gy	8	vio	136
9	gy	8	vio	136
10	blu	11	blu-wht	33
12	blu	11	blu-wht	33
17	grn	18	yel-grn	6.3
19	grn	18	yel-grn	6.3
20	yel	21	grn-wht	3.15
22	yel	21	grn-wht	3.15
13	blk	14	wht-blk	115
15	blk-grn	16	blk-red	115

③ Measured with respect to +100

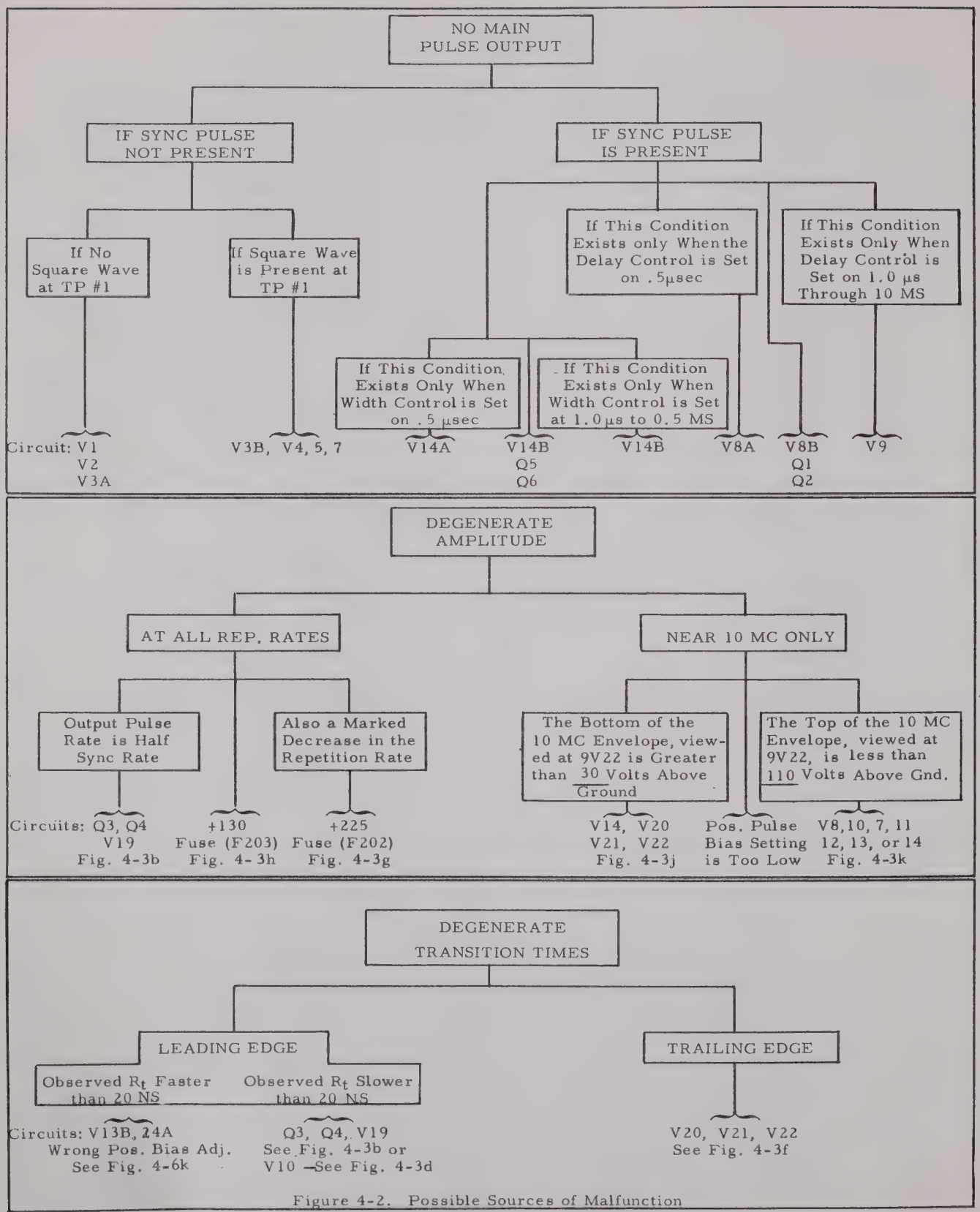
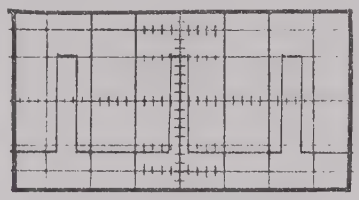

NO MAIN PULSE OUTPUT
IF SYNC PULSE NOT PRESENT
IF SYNC PULSE IS PRESENT
If No Square Wave at TP #1
If Square Wave is Present at TP #1
If This Condition Exists only When the Delay Control is Set on .5μsec
If This Condition Exists Only When Delay Control is Set on 1.0 μs Through 10 MS
If This Condition Exists Only When Width Control is Set on .5 μsec
If This Condition Exists Only When Width Control is Set at 1.0 μs to 0.5 MS
Circuit: V1 V2 V3A
V3B, V4, 5, 7
V14A
V14B Q5 Q6
V14B
V8A
V8B Q1 Q2
V9
DEGENERATE AMPLITUDE
AT ALL REP. RATES
NEAR 10 MC ONLY
Output Pulse Rate is Half Sync Rate
Also a Marked Decrease in the Repetition Rate
The Bottom of the 10 MC Envelope, viewed at 9V22 is Greater than 30 Volts Above Ground
The Top of the 10 MC Envelope, viewed at 9V22, is less than 110 Volts Above Gnd.
Circuits: Q3, Q4 V19 Fig. 4-3b
+130 Fuse (F203) Fig. 4-3h
+225 Fuse (F202) Fig. 4-3g
V14, V20 V21, V22 Fig. 4-3j
Pos. Pulse Bias Setting is Too Low
V8,10, 7, 11 12, 13, or 14 Fig. 4-3k
DEGENERATE TRANSITION TIMES
LEADING EDGE
TRAILING EDGE
Observed R_t Faster than 20 NS
Observed R_t Slower than 20 NS
Circuits: V13B, 24A Wrong Pos. Bias Adj. See Fig. 4-6k
Q3, Q4, V19 See Fig. 4-3b or V10 —See Fig. 4-3d
V20, V21, V22 See Fig. 4-3f

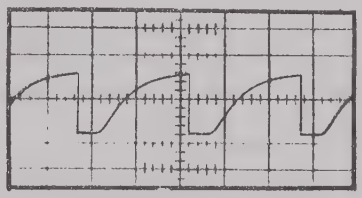
Figure 4-2. Possible Sources of Malfunction

Figure 4-3. Waveform Analysis in Troubleshooting

Figures 4-3a through 4-3d were photographed from a Tektronix 541 Oscilloscope equipped with a Type CA Plug-In. Oscilloscope Settings: Sweep Speed -- 20 μs/cm; Vertical Deflection -- 20v/cm. Pulse Generator Settings: Repetition Rate -- 2 kc; Delay -- 0; Width -- 10 μs.

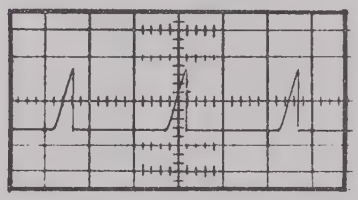
(a) Proper Waveform

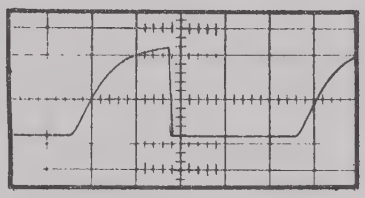




(b) Output Waveform showing effect of defective flip-flop or gate tube

(c) Output Waveform with V13B and V24A defective

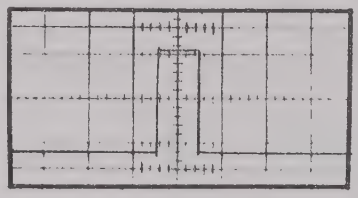


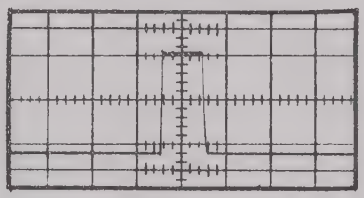


(d) Output Pulse with V10 defective

For Figures 4-3e and 4-3f, the scope sweep speed was changed to 10μs/cm.

(e) Proper Waveform

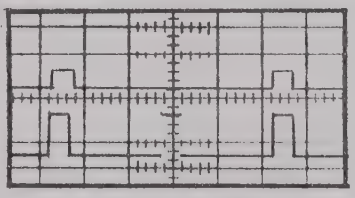


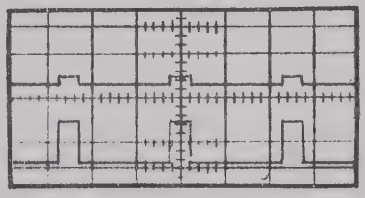


(f) Output Pulse showing loss of trailing edge

Settings for Figures 4-3g and 4-3h were the same as Figures 4-3a -- 4-3d, except Vert. Defl. was 50v/cm

(g) Double Exposure of Output Waveform before (bottom) and after (top) +225 fuse blew.

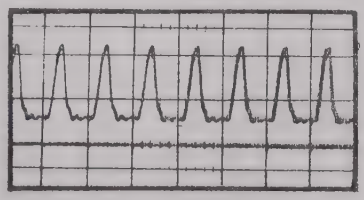




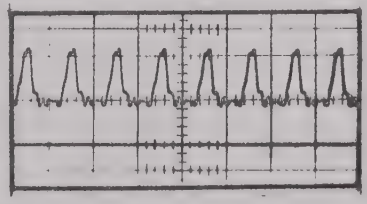
(h) Double Exposure of Output Waveform before and after +130 fuse blew

Figures 4-3i through 4-3k were photographed on a Tektronix Type 541 Oscilloscope with Type CA Plug-In Oscilloscope Settings: Sweep Speed -- 0.1 μs/cm; Vertical Deflection -- 50v/cm. Pulse Generator Settings: Repetition Rate -- 10 mc; Delay -- min.; Width -- min.

(i) Proper 10 mc Waveform viewed at 9V22

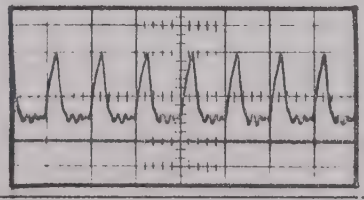


gnd



(j) 10 mc Waveform at 9V22 with insufficient trailing edge amplification.

(k) 10 mc Waveform at 9V22 with insufficient leading edge amplification



gnd

4.4 CALIBRATION PROCEDURE

4.4.1 General: Remove top and bottom dust covers. Connect the instrument and ac ammeter and ac voltmeter to the autotransformer output. Set at 115v ac. Allow 30 minutes warm-up before calibrating. Make sure the instrument is working properly before commencing. If any portion of the instrument fails to calibrate, repair should be effected before attempting to complete calibration.

4.4.2 Calibration Equipment Required:

1) AC ammeter with a 5.0 amp range.
2) RMS reading ac voltmeter with a range of 0-150 volts (0-300 for 230 volt operation).
3) Variable line transformer with a rating of at least 7.5 amperes such as the Powerstat Model 116.
4) Multimeter with a dc accuracy of 1-1/2% and sensitivity of 20,000 ohms per volt.
5) General purpose 0-30 mc bandpass scope with either delayed sweep or high sweep magnification and a high gain vertical amplifier (5 mv/cm). The Tektronix Type 543 with Type L plug-in is adequate. A dual trace plug-in is convenient but not essential.
6) 100 mc or better band pass scope such as HP Model 185.
7) 50-ohm, 20-watt termination such as DATAPULSE Model 1002.
8) Source of 0-10 mc 5-volt triggers and 20v gates with rise and fall time less than 0.1 μs. DATAPULSE Model 104 exceeds both requirements.
9) Audio generator with at least 5v rms output continuously variable from 10 cps to 1 mc.
10) Two clip leads.
11) A 2k-10w resistor.
12) A 10k-10w resistor.
13) An insulated, low capacity screwdriver.

4.4.3 Power Supply Calibration: (See Figure 4-4) Since the timing circuits are dependent upon the regulated power supplies for reference, any variance of these voltages will necessarily cause a change in calibration accuracy. Therefore, these adjustments must not be attempted except when the instrument is being completely calibrated.

Place REPETITION RATE control on EXT.
Set DIVIDED SYNC DIVISION ADJUST to OFF.
Set POLARITY TO "+".

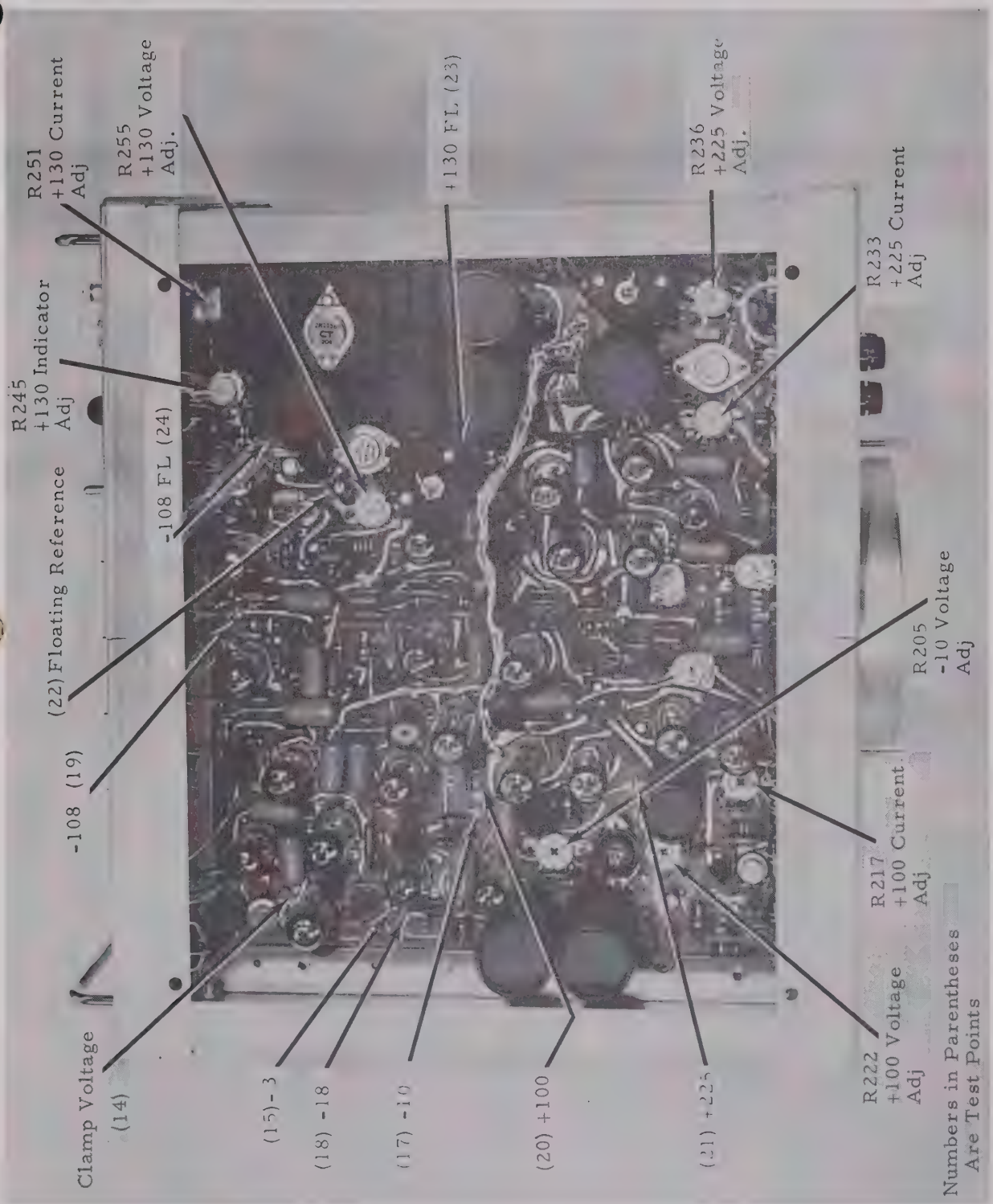


Figure 4-4. Power Supply Calibration Adjustments and Test Points

4.4.3.1 Voltage Calibration (Refer to Table IV). Measure the output voltages (listed in column 1) with respect to ground at those test points indicated in the second column. Correct those voltages that are outside of tolerance. Proceed in the indicated sequence. To check the supplies for proper regulation, vary the line voltage from 105 to 125v ac. All of the voltages should remain essentially constant.

If a voltage (1) does not meet tolerance or come into tolerance with adjustment, (2) exceeds tabulated ripple, or (3) varies excessively with line voltage; correct the trouble before proceeding.

TABLE IV
VOLTAGE CALIBRATION

Voltage	Test Point	Tolerance	Max. Ripple	Adj.
-18	TP18	+10%	200 mv	--
* -10	TP17	±5%	75 mv	R205
* -4.5	TP16	4.0-4.5 v	20 mv	--
-108	TP19	±3%	300 mv	--
+100	TP20	±2%	10 mv	R222
+225	TP21	±2%	200 mv	R236
+130 **	TP23	±5%	200 mv	R255
-108 **	TP24	±3%	.7 v	--

* It is not necessary to make regulation checks on these voltages.
** Floating

4.4.3.2 Power Supply Current Limiting Calibration:

a. +100: Clip 2k-10w resistor from TP20 to ground. Set REPETITION RATE controls for 9 MC/S; PULSE DELAY and PULSE WIDTH controls for minimum. Adjust each of these three VERNIERS for a peak in instrument line current. (Do not exceed 100% delay width duty cycle). While observing the +100 output on a dc voltmeter, turn R217 "100 CUR ADJ" clockwise until +100 output begins to drop. Remove resistor and clip leads.

b. +225: Clip 10k-2w resistor from TP21 to ground. Tune for maximum instrument line current as described above while observing the +225 output on a dc voltmeter, turn R233 clockwise until +225 output begins to drop. Remove resistor.

c. +130 Floating: Set PRF to precisely 1 kc as observed on a scope with an accurately calibrated sweep. With scope sweep speed at 50 μs/cm set pulse width for exactly 8 cm. Set POLARITY to "-", and terminate output with 50 ohms. Measure the dc voltage from TP23 to TP22. Turn "+130 CUR ADJ." fully counterclockwise. Turn this pot. clockwise slowly until +130 output dips two volts.

Turn PULSE WIDTH VERNIER back and forth through the overload threshold (the point at which the +130 output drops) while adjusting R245 "+130 IND. ADJ." such that the AVERAGE PULSE CURRENT OVERLOAD indicator strikes a few degrees of PULSE WIDTH VERNIER rotation prior to actual overload.

4.4.4 Repetition Rate Calibration: (See Figure 4-5)

a. Preliminary Settings
   (1) REPETITION RATE control to 10 cps, VERNIER fully clockwise (cw).
   (2) PULSE DELAY control to 0.5 μs, VERNIER fully counterclockwise (ccw).
   (3) PULSE WIDTH control to 0.5 ms, VERNIER cw.
   (4) POLARITY to "+"; ATTENUATION controls fully cw; RISE TIME fully ccw; terminate pulse output into 50-ohm load (DI #1002)

b. View pulse on a calibrated sweep oscilloscope. Set R14 "rep rate cal" for 0.1 second pulse spacing (10 cps).

c. Check oscillator ranges from 10 cps to 0.5 MC/S and insure that calibration is within ±10% (It may be necessary to readjust R14 so that all ranges from 10 cps to 0.5 MC/S are within ±10%.

d. REPETITION RATE switch to 5 MC/S; VERNIER cw. Adjust C308 and C315 for a pulse spacing of 0.2 μs (5 mc). View square wave at TP 1. Maintain waveform form symmetry by adjusting C308 and C315. Check the "2 MC/S" and "1 MC/S" ranges to verify that they are within ±10%.

e. REP. RATE to 10 MC/S; VERNIER cw. Adjust C309 and 316 for pulse spacing of 0.1 μs (10 mc).

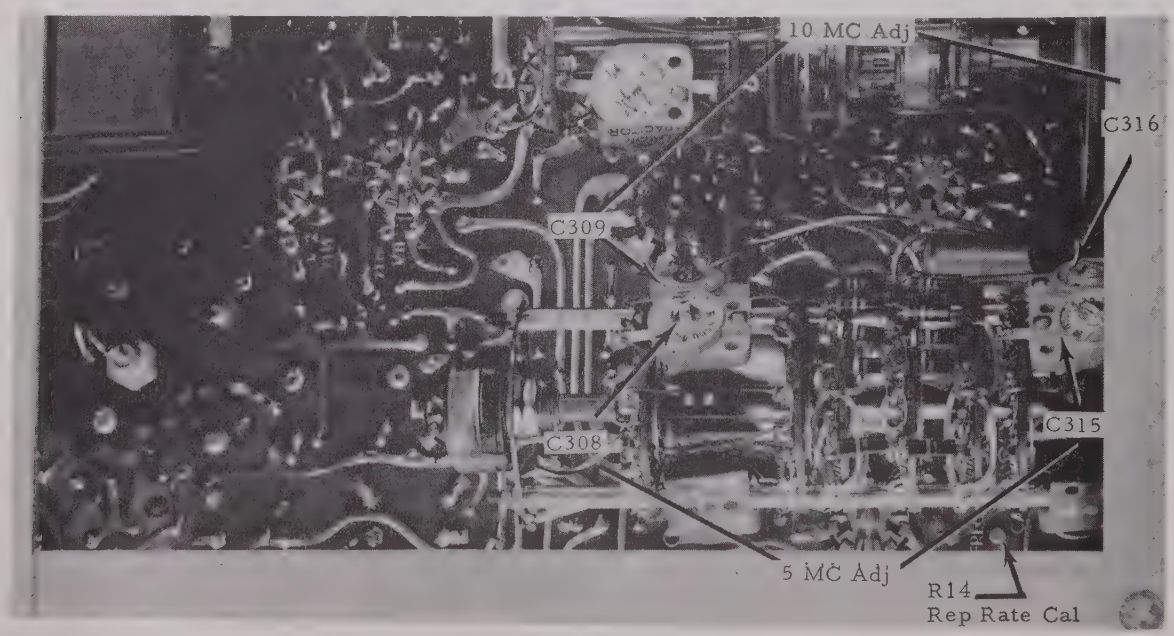


Figure 4-5. Repetition Rate Controls

4.4.5 Pulse Delay Calibration: (See Figure 4-10).

Maintain PULSE DELAY VERNIER fully clockwise. Set POLARITY to "+". Set ATTENUATION controls to "0" db. View main pulse on a 30 mc general purpose scope with well calibrated sweep. A dual trace scope is convenient. Calibrate in the sequence tabulated in Table V. Check all ranges in succession to see that they fall within ±5%. Notice which ranges are "long" and "short". If any should fall outside the ±5% tolerance, readjust the appropriate calibration control such that the outside range is "long" by the same margin that the shortest range is "short" or vice versa. Maintain a pulse delay duty cycle of 1/20th.

TABLE V
PULSE DELAY CALIBRATION

CONTROL SETTING				This Adjust
Rep. Rate	Pulse Delay	Pulse Width	Calibration Adjustment	Also Calibrates
10cps	5 ms	500 µs	R405	All
20cps	2 ms	500 µs	R411	All
10cps	Repeat 5 ms	500 µs	R405	All
5 cps	10 ms	500 µs	R409	1 µs, 10 µs, .1 ms, 1 ms, 10 ms.
1 kc	5 µs	5 µs	C402	5 µs, 10 µs, 20 µs
5 kc	1 µs	1 µs	C401	1 µs, 2 µs

4.4.6 Pulse Width Calibration: Set PULSE DELAY control at 0.5 MICROSEC., VERNIER ccw. Maintain PULSE WIDTH VERNIER fully cw. Set Polarity to "+". Set ATTENUATION controls to "0" db. View main pulse on a 30 mc general purpose scope with a well calibrated sweep. Calibrate in the sequence tabulated in Table VI. Check all ranges in succession to see that they fall within ±5%. Notice which ranges are "long" and "short". If any should fall outside the ±5% tolerance, readjust the appropriate calibration control such that the outside range is "long" by the same margin that the shortest range is "short" or vice versa. Maintain a pulse width duty cycle of 1/20th.

TABLE VI
PULSE WIDTH CALIBRATION

CONTROL SETTING		Calibration	This Adjust.
Rep. Rate	Pulse Width	Adjustment	Also Calibrates
100 cps	0.5 millisec	R505	All
200 cps	0.2 millisec	R511	All
100 cps	Repeat 0.5 Millisec	R505	All
500 cps	0.1 millisec	R509	1 µs, 10 µs 0.1 millisec
1 kc	5 microsec	C502	5 µs, 10 µs, 20 µs
5 kc	1 microsec	C501	1 µs, 2 µs

4.4.7 Output Waveform Calibration: (See Waveforms -- Figure 4-6a through 4-6k). Because the rise time of the output waveform is faster that the rated response of most general purpose (30 mc) oscilloscopes, exact observation and rise time measurements may not be made without resorting to either a sampling oscilloscope or traveling wave oscilloscope. A slower scope may be used, but generally there is considerable inductance in the deflection plate adapter, and the slower sweep speed, on the order of 20 nanosec. per centimeter, makes resolution difficult. A general purpose oscilloscope is sufficient for rough trimming of output waveform and making top slope adjustment for wide pulses.

a. Rough Trimming: Waveforms shown in this section were taken with a Tektronix Type 541 oscilloscope with Type CA Plug-In.

(1) Set REPETITION RATE control to EXT., VERNIER ccw; set PULSE DELAY to 0.5 microsec., VERNIER cw; set PULSE WIDTH to 0.5 millisec., VERNIER cw; set POLARITY to "+"; set both ATTENUATION controls for "0" db. Terminate output pulse into 50 ohms.

(2) Set R107 (POS. BIAS) for the output pulse baseline at 0.5v above ground.

(3) Set POLARITY TO "-", adjust R107 (NEG. BIAS) for a baseline ≤ 5 mv below ground.

(4) Set POLARITY switch to "+"; set REP. RATE control to 0.1 KC/S; set RISE TIME control ccw. Adjust R98 (TOP SLOPE) for minimum top slope.

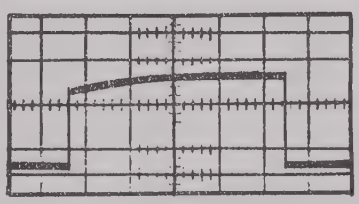


Figure 4-6a. Top Slope (R98) Over-Compensated. Sweep Speed 10µs/cm, Vert. Deflection 20v/cm, Rep. Rate 2 kc, Delay, Width 50 µs.

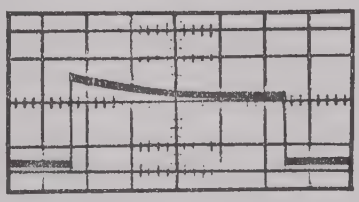


Figure 4-6b. Top Slope Undercompensated. Control settings same as (a) above.

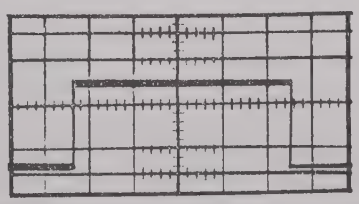


Figure 4-6c. Top Slope Properly Compensated. Same settings as (a).

(5) Rep. rate = 200 cps Set PULSE WIDTH control to 0.2 MILLISEC. Adjust C59 (ROLL) for minimum top slope in the area between 5 and 30 microseconds following the leading edge.

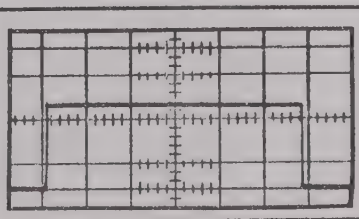


Figure 4-6d. Roll Control (C59) Over-Compensated. Settings same as (a) except Width is 60 µs.

Figure 4-6e. Roll Control Undercompensated. Settings same as 4-6d.

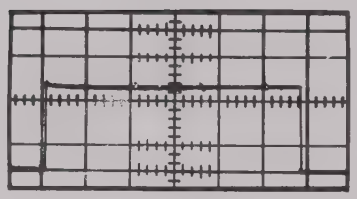
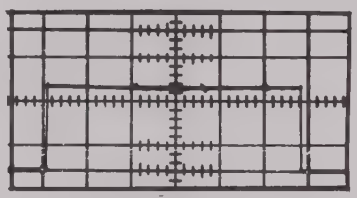


Figure 4-6f. Roll Control Properly Adjusted. Settings same as 4-6d.



(6) Set PULSE WIDTH to 1 μs; set repetition rate to 10 kc. Adjust C42 (overshoot) for squarest leading edge with minimum overshoot.

Figure 4-6g. Overshoot Control Over-Compensated. Scope Sweep Speed -- 0.5μs/cm, Vert. Defl.--20v/cm, Rep. Rate --10 kc, Delay -- 3μs/cm, Width -- 1μs.

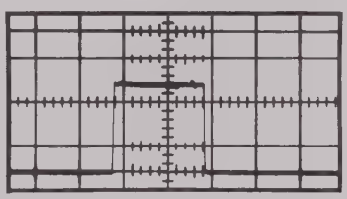


Figure 4-6h. Overshoot Control Undercompensated. Settings same as (g).

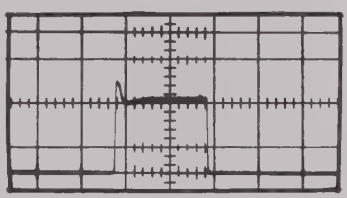
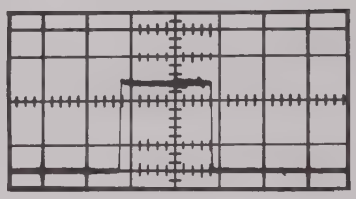


Figure 4-6i. Overshoot Control properly adjusted. Settings same as (g).



(7) Repeat steps (5) and (6) until further adjustment is unnecessary.

b. Fine Tuning: Waveforms depicted in this section were taken on a Hewlett-Packard Model 185 Sampling Scope with Model 187B Dual Trace Preamplifier. Fine adjustment of C42 (overshoot) R107 (Pos Bias), R104 (Neg Bias), C60, C74, and C75 should be performed on a fast response oscilloscope. Readjustment of Pos Bias R107 may be necessary to obtain specified rise time.

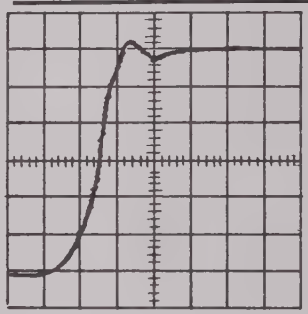


Figure 4-6j.
10 ns/cm
Typical Output
with Proper Bias.

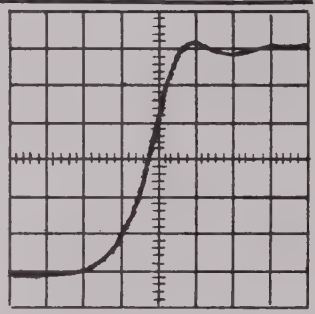


Figure 4-6k.
10 ns/cm
Typical Output
With Improper Bias.

(Outputs shown at max. ampl. and 100 kc rep. rate.)

Rise time control may be turned slightly CW to help trim any ringing on leading edge. At this point both rise and decay times should be ≤10 nanoseconds. Because of the wide variation of all controls some combinations of settings may be found that will cause slight oscillations on the flat top. Slight alteration of any control usually eliminates this condition.

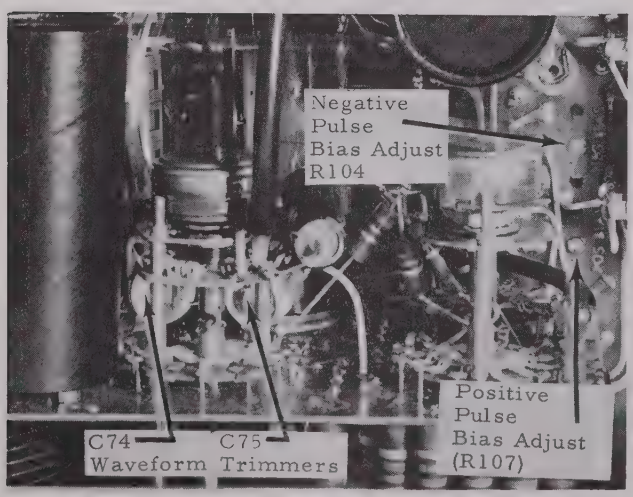


Figure 4-7. Output Waveform Adjustments

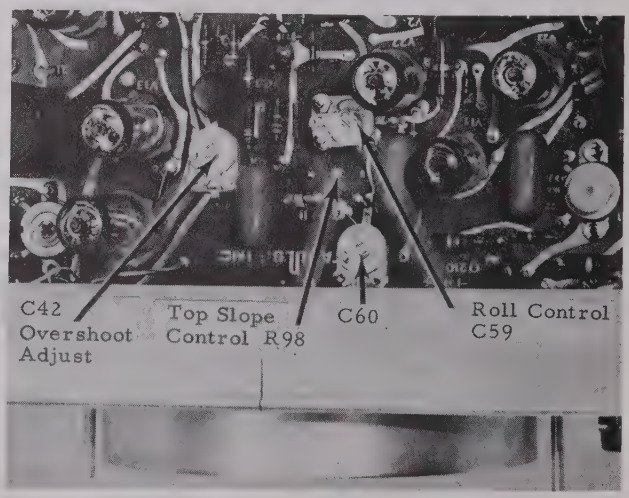


Figure 4-8. Output Waveform Adjustments

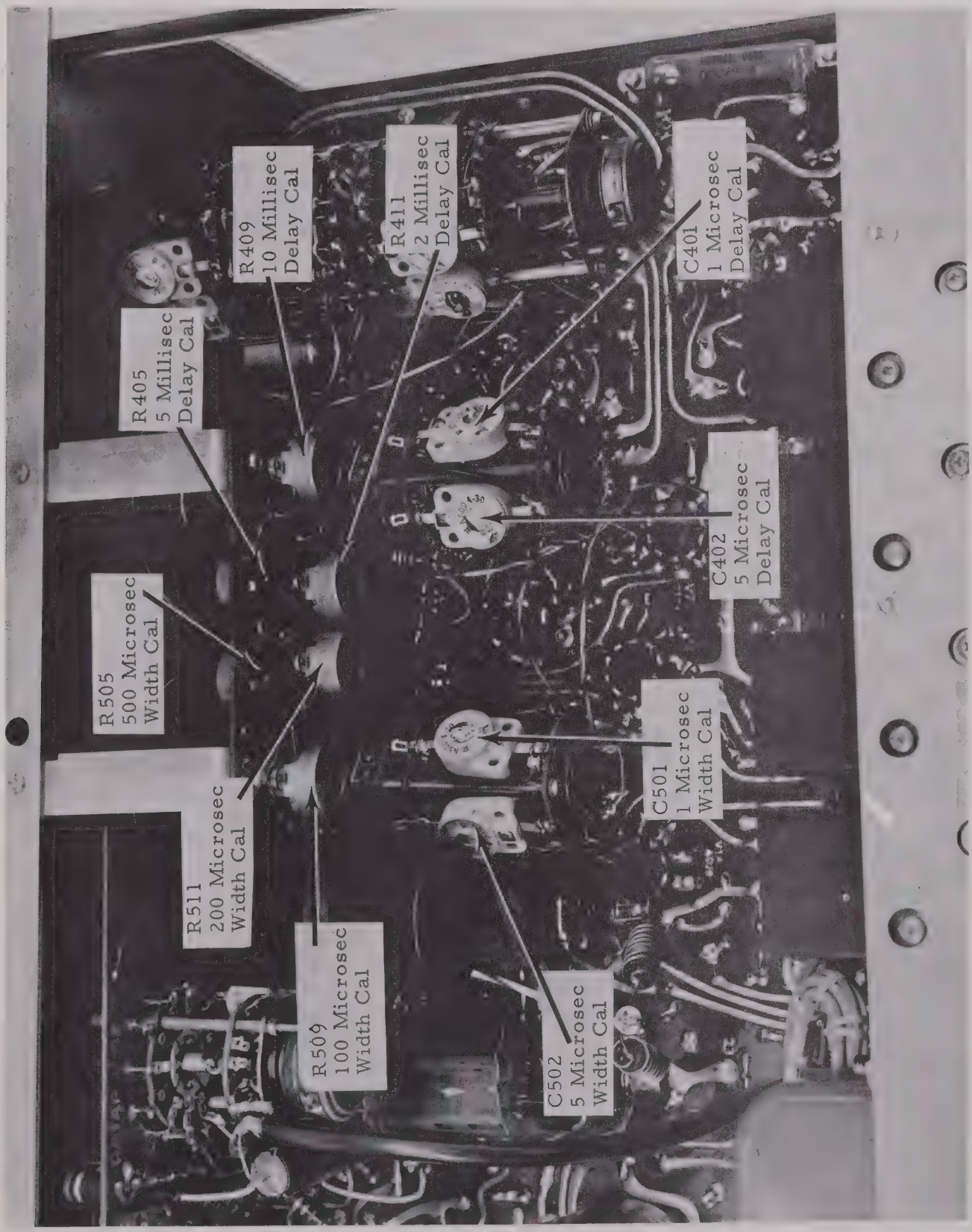


Figure 4-9. Pulse Delay and Pulse Width Calibration Adjustments

4.5 SPECIFICATIONS VERIFICATION

The following detailed test was performed on this instrument just prior to shipment to confirm published specifications. Before the test was conducted this instrument had been thoroughly aged and had undergone rigid examination for workmanship and appearance. This procedure is provided to assist you in performing tests of this type. Re-calibrate and/or troubleshoot the instrument if specifications are not verifiable.

4.5.1 Equipment Required:
Oscilloscope, 30 MC
Oscilloscope, 100 MC
Multimeter
Termination
Signal Generator
Auto Transformer
Line Voltmeter

4.5.2 Repetition Rate.

a. Oscillator Timing: Set PULSE DELAY control to .5 μs; set DELAY VERNIER ccw. Set POLARITY switch to "+"; set RISE TIME VERNIER ccw. Set ATTENUATION controls to "O" db, and terminate output into 50 ohms. Sync scope from DIVIDED SYNC OUTPUT for first two steps of Table VII; thereafter POSITIVE SYNC PULSE OUTPUT.

To check oscillator timing calibration follow the panel control setting sequence shown in Table VII. Count the pulses appearing on a 10-cm graticule. Calibration accuracy is satisfactory if the pulse count is 9 to 11 when the VERNIER is cw; or if the pulse count is less than 10 when the VERNIER is ccw.

b. Jitter: Set PULSE DELAY control to 0.5 μs. Set PULSE WIDTH control to 0.5 μs. Set REPETITION RATE control to 100 kc; set REP. RATE VERNIER cw. Set scope sweep speed to 10 μs/cm; expand sweep to X100.

Observe the leading edge of the 10th pulse. Jitter should be less than 0.2 centimeter.

c. External Triggering and Single Pulse. (See Table VIII)

d. Sync Pulse: Set PULSE WIDTH control to 0.5 μs; set WIDTH VERNIER ccw. Set PULSE DELAY control to 0.5 μs; set DELAY VERNIER ccw. Set REPETION RATE control to 10 MC/S; set REP. RATE VERNIER ccw.

Measure the amplitude of each sync terminated into 100 ohms. For a 10-volt sync the amplitude should be greater than 10v. For a 1-volt sync the amplitude should be 2.0 to 1.0 volt. For a DIVIDED SYNC the amplitude should be greater than 8v.

e. Gated-Not Gated: Set PULSE DELAY 0.5 μs; set DELAY VERNIER ccw. Set PULSE WIDTH to 0.5 μs; set WIDTH VERNIER ccw. Set REPETITION RATE control to 10 mc;

TABLE VII
REPETITION RATE CALIBRATION CHECK

Rep. Rate Range	SCOPE SWEEP SPEED		Pulse Width
	Rep. Rate Vernier cw	Rep. Rate Vernier ccw	
10 mc	.1 μs/cm	.2 μs/cm	min
5 mc	.2 μs/cm	.5 μs/cm	min
2 mc	.5 μs/cm	1 μs/cm	min
1 mc	1 μs/cm	2 μs/cm	min
.5 mc	2 μs/cm	5 μs/cm	min
.2 mc	5 μs/cm	10 μs/cm	min
.1 mc	10 μs/cm	20 μs/cm	min
50 kc	20 μs/cm	50 μs/cm	1 μs
20 kc	50 μs/cm	100 μs/cm	1 μs
10 kc	100 μs/cm	200 μs/cm	1 μs
5 kc	200 μs/cm	500 μs/cm	10 μs
2 kc	500 μs/cm	1 ms/cm	10 μs
1 kc	1 ms/cm	2 ms/cm	10 μs
.5 kc	2 ms/cm	5 ms/cm	100 μs
.2 kc	5 ms/cm	10 ms/cm	100 μs
.1 kc	10 ms/cm	20 ms/cm	100 μs
50 cps	20 ms/cm	50 ms/cm	500 μs
20 cps	50 ms/cm	100 ms/cm	500 μs
10 cps	100 ms/cm	200 ms/cm	500 μs

TABLE VIII
EXTERNAL AND SINGLE TRIGGERING CHECK

SWEEP SPEED	PULSE DELAY		PULSE WIDTH		APPLY	VERIFY
	CONTROL	VERNIER	CONTROL	VERNIER		
1 μs/cm	.5 μs	ccw	.5 μs	ccw	5v rms sine wave at 1 mc to POSITIVE EXTERNAL TRIGGER INPUT jack	Triggering Stability
.1 μs/cm	.5 μs	ccw	.5 μs	ccw	5v positive pulse at 10 mc PRF to POSITIVE EXT. TRIGGER INPUT jack	Triggering Stability
.1 milli-sec/cm	.5 milli-sec.	ccw	.5 milli-sec.	cw	One depression of SINGLE PULSE pushbutton	Occurrence of Single Pulse

set REP. RATE VERNIER cw.

Apply a 20v 0.1 μs rise positive gate to the POS. GATE INPUT jack. Set the GATED-NOT GATED switch on GATED to verify that the instrument is being controlled by the external gating signal.

4.5.3 Pulse Delay.

a. Delay Timing

Set POLARITY switch on POS. Turn RISE TIME control fully ccw. Set ATTENUATION control fully cw. Terminate output pulse into 50 ohms, sync scope from Positive Sync Output. View output pulse simultaneously (dual trace).

Note that delay is measured from the 50% point on the leading edge of the sync pulse to the 50% point on the leading edge of the output pulse. To check pulse delay timing, refer to the panel control sequence shown in Table VIII.

b. Duty Cycle: Set PULSE REPETITION RATE switch to 0.1 kc/s and scope sweep speed to 2 ms/cm. Slowly turn PULSE DELAY VERNIER cw and verify that 70% duty cycle can be exceeded without circuit failure.

c. Jitter: Set PULSE DELAY control to 1 millisec; set DELAY VERNIER cw. Set the scope sweep speed at 0.2 ms/cm. Expand sweep to X100. View the leading edge of the pulse. Jitter should be less than 1/2 cm (0.1%).

4.5.4 Pulse Width.

a. Pulse Width Timing: Set POLARITY control to "+"; set RISE TIME control ccw; set ATTENUATION controls fully cw. Terminate output pulse into 50 Ω. Sync scope from leading edge of the output pulse. View the output pulse. Measure width from the 50% point on the leading edge of the output pulse to the 50% point on the lagging edge of the output pulse. To verify pulse width timing proceed according to the panel control settings shown in Table IX.

b. Duty Cycle: Remove 50 Ω termination. Set PULSE REPETITION RATE control to 10 kc/s and scope sweep speed to 20μs/cm. Slowly turn PULSE WIDTH VERNIER cw. Verify that 70% duty cycle can be exceeded without circuit failure.

c. Jitter: Set PULSE WIDTH control to .5 millisec; set WIDTH VERNIER cw. Set scope sweep at .1 ms/cm. Expand sweep speed to X100. View the trailing edge of the pulse. Jitter should be less than 1/2 cm (0.1%)

4.5.5 Output Pulse Waveform.

a. Amplitude: Set pulse REPETITION RATE switch to 10 MC/S; set REP. RATE VERNIER cw. Set PULSE DELAY to 0.5 μs; set DELAY VERNIER ccw. Set PULSE WIDTH to 0.5 μs; set WIDTH VERNIER ccw. Set POLARITY to "+"; set RISE TIME ccw. (Continued)

TABLE IX
PULSE DELAY CALIBRATION CHECK

REPETITION RATE	PULSE WIDTH	PULSE DELAY		SCOPE SWEEPSPEED	Separation Between Sync And Leading Edge Must Be	
		CONTROL	VERNIER		AT LEAST	BUT NOT GREATER THAN
1 kc/s	1 μs	0.5 μs	ccw	0.1 μs/cm	0	0.5 cm
1 kc/s	1 μs	0.5 μs	cw	0.1 μs/cm	4.75 cm	5.25 cm
1 kc/s	1 μs	1 μs	cw	0.2 μs/cm	4.75 cm	5.25 cm
1 kc/s	1 μs	2 μs	cw	0.5 μs/cm	3.8 cm	4.2 cm
1 kc/s	1 μs	5 μs	cw	1 μs/cm	4.75 cm	5.25 cm
1 kc/s	1 μs	10 μs	cw	2 μs/cm	4.75 cm	5.25 cm
1 kc/s	1 μs	20 μs	cw	5 μs/cm	3.8 cm	4.2 cm
1 kc/s	1 μs	50 μs	cw	10 μs/cm	4.75 cm	5.25 cm
1 kc/s	1 μs	0.1 ms	cw	20 μs/cm	4.75 cm	5.25 cm
0.1 kc/s	1 μs	0.2 ms	cw	50 μs/cm	3.8 cm	4.2 cm
0.1 kc/s	1 μs	0.5 ms	cw	0.1 ms/cm	4.75 cm	5.25 cm
0.1 kc/s	1 μs	1 ms	cw	0.2 ms/cm	4.75 cm	5.25 cm
10 cps	0.1 ms	2 ms	cw	0.5 ms/cm	3.8 cm	4.2 cm
10 cps	0.1 ms	2 ms	ccw	0.1 ms/cm	------	9.5 cm
10 cps	0.1 ms	5 ms	ccw	0.2 ms/cm	------	9.5 cm
10 cps	0.1 ms	5 ms	cw	1 ms/cm	4.75 cm	5.25 cm
10 cps	0.1 ms	10 ms	cw	2 ms/cm	4.75 cm	5.25 cm
10 cps	0.1 ms	10 ms	ccw	0.5 ms/cm	------	9.5 cm

4.5.5 Output Pulse Waveform (Continued)

Set attenuator controls cw. Sync scope from POSITIVE SYNC OUTPUT. View output pulse terminated into 50 Ω; set scope sweep speed to 0.1 μs/cm and vertical sensitivity to 20v/cm. Amplitude should be equal to or greater than 36v. Set POLARITY to "-". Amplitude should again be equal to or greater than 36v.

Repeat the above observations at 8 mc repetition rates. Amplitudes should be equal to or greater than 40v.

Set POLARITY to "+". Step the 2 db attenuator from 2 to 10 db, observing step accuracies to be within approximately 10%.

Return all attenuation controls to the cw position. Step the 10 db attenuator from 10 to 50 db, observing step accuracies to be within approximately 10%.

b. Overshoot: Set ATTENUATION controls cw. Set REPETITION RATE to 10 kc; set REP. RATE VERNIER ccw. Set PULSE WIDTH to 1.0 μs; set WIDTH VERNIER cw.

Overshoot should be less than 5% (it may be necessary to trim overshoot somewhat with rise time control).

c. Rise Time: Set RISE TIME control fully cw.

Rise time should be greater than 0.2 μs.

d. Top Slope: Set REPETITION RATE control to 50 cps. Set PULSE WIDTH to 0.5 ms. Set scope sweep speed to 0.2 ms/cm.

Top slope should be less than 3%.

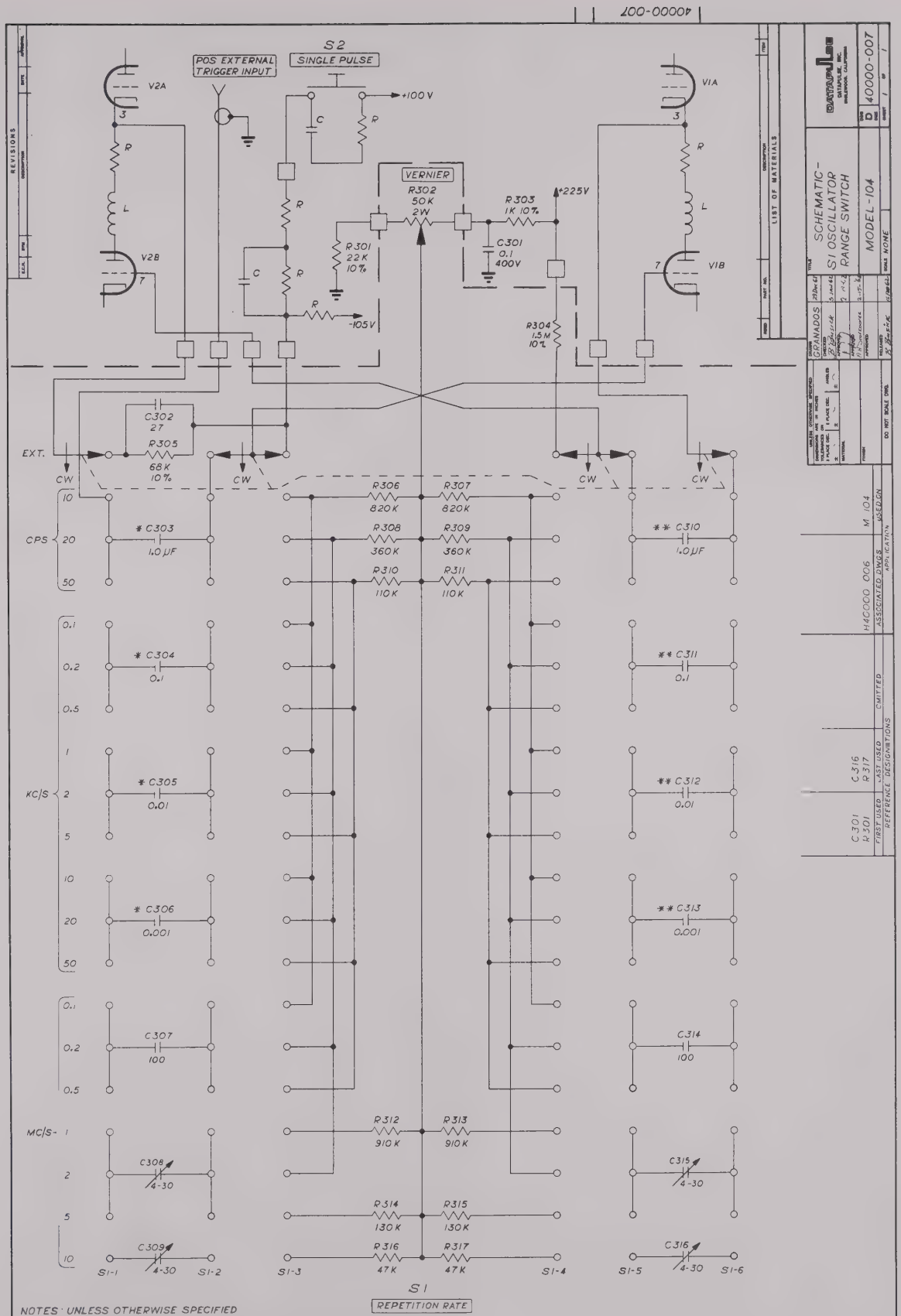
e. 50 Ω Termination: Set REPETITION RATE control to 10 kc. Set PULSE WIDTH to 0.5 μs; set WIDTH VERNIER fully ccw. Observe output waveform terminated into 50 Ω on a sampling oscilloscope. Rise and decay times should be equal to or less than 10 nanoseconds (from 10% point on leading edge to 90% point on lagging edge).

4.5.6 Pulse Current Overload.

Set PRF to exactly 1 kc as observed on scope. Set PULSE DELAY control to 0.5 μs; set DELAY VERNIER ccw. Set PULSE WIDTH control to 0.5 ms; set DELAY VERNIER ccw. Set POLARITY to "-". Terminate output in 50 Ω. Place dc voltmeter from TP23 to TP22. With scope sweep speed set at 50 μs/cm turn PULSE WIDTH VERNIER cw noting the voltage reading. Output should drop 5v at 7.5± .3 cm Pulse Duration. The indicator lamp should strike at approximately this same pulse width.

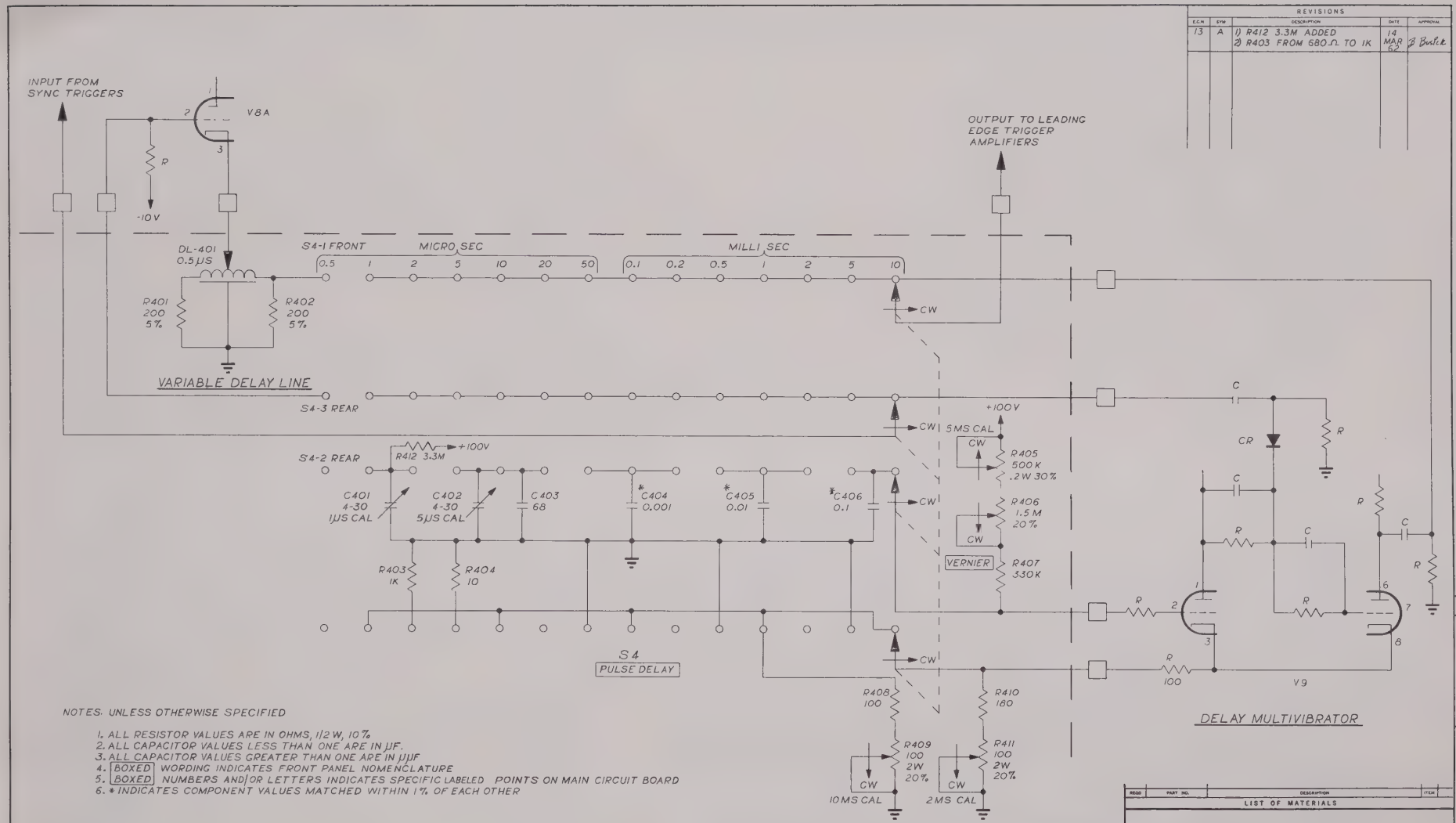
TABLE X
PULSE WIDTH CALIBRATION CHECK

REPETITION RATE	PULSE WIDTH		SCOPE SWEEP SPEED	Separation Between Leading Edge & Trailing Edge Must Be	
	CONTROL	VERNIER		AT LEAST	BUT NOT GREATER THAN
1 kc/s	0.5 μs	ccw	0.1 μs/cm with X5 Mult.		1 cm
1 kc/s	0.5 μs	cw	0.1 μs/cm	4.75 cm	5.25 cm
1 kc/s	1 μs	cw	0.2 μs/cm	4.75 cm	5.25 cm
1 kc/s	2 μs	cw	0.5 μs/cm	3.8 cm	4.2 cm
1 kc/s	5 μs	cw	1 μs/cm	4.75 cm	5.25 cm
1 kc/s	10 μs	cw	2 μs/cm	4.75 cm	5.25 cm
1 kc/s	20 μs	cw	5 μs/cm	3.8 cm	5.25 cm
1 kc/s	50 μs	cw	10 μs/cm	4.75 cm	5.25 cm
1 kc/s	0.1 ms	cw	20 μs/cm	4.75 cm	5.25 cm
1 kc/s	0.1 ms	ccw	5 μs/cm	------	9.5 cm
0.1 kc/s	0.2 ms	ccw	10 μs/cm	------	9.5 cm
0.1 kc/s	0.2 ms	cw	50 μs/cm	3.8 cm	4.2 cm
0.1 kc/s	0.5 ms	cw	100 μs/cm	4.75 cm	5.25 cm
0.1 kc/s	0.5 ms	ccw	20 μs/cm	------	9.5 cm



NOTES: UNLESS OTHERWISE SPECIFIED

1. • INDICATES COMPONENT VALUES MATCHED WITHIN 1 % OF EACH OTHER.
2. ▪▪ INDICATES COMPONENT VALUES MATCHED WITHIN 1% OF EACH OTHER.
3. BOXED WORDING INDICATES FRONT PANEL NOMENCLATURE
4. BOXED NUMBERS AND/OR LETTERS INDICATES SPECIFIC LABELED POINTS ON MAIN CIRCUIT BOARD.
5. ALL RESISTOR VALUES ARE IN OHMS 1/2 W 5% .
6. ALL CAPACITOR VALUES LESS THAN ONE ARE IN µF.
7. ALL CAPACITOR VALUES GREATER THAN ONE ARE IN µµF.



NOTES: UNLESS OTHERWISE SPECIFIED

1. ALL RESISTOR VALUES ARE IN OHMS, 1/2 W, 10%
2. ALL CAPACITOR VALUES LESS THAN ONE ARE IN µF.
3. ALL CAPACITOR VALUES GREATER THAN ONE ARE IN µµF
4. [BOXED] WORDING INDICATES FRONT PANEL NOMENCLATURE
5. [BOXED] NUMBERS AND/OR LETTERS INDICATES SPECIFIC LABELED POINTS ON MAIN CIRCUIT BOARD
6. * INDICATES COMPONENT VALUES MATCHED WITHIN 1% OF EACH OTHER

REVISIONS

E.C.N.	SYM	DESCRIPTION	DATE	APPROVAL
13	A	1) R412 3.3M ADDED 2) R403 FROM 680Ω TO 1K	14 MAR 62	B Burtch

LIST OF MATERIALS

REQD	PART NO.	DESCRIPTION	ITEM

REFERENCE DESIGNATION			APPLICATION	
FIRST USED	LAST USED	OMITTED	ASSOCIATED DWGS	USED ON
DL-401 C401 R401	DL-401 C406 R412		H 40000-006	M-104

UNLESS OTHERWISE SPECIFIED DIMENSIONS ARE IN INCHES TOLERANCES ON 2 PLACE DEC. ± 3 PLACE DEC. ± ANGLES ±
MATERIAL
FINISH
DO NOT SCALE DWG.

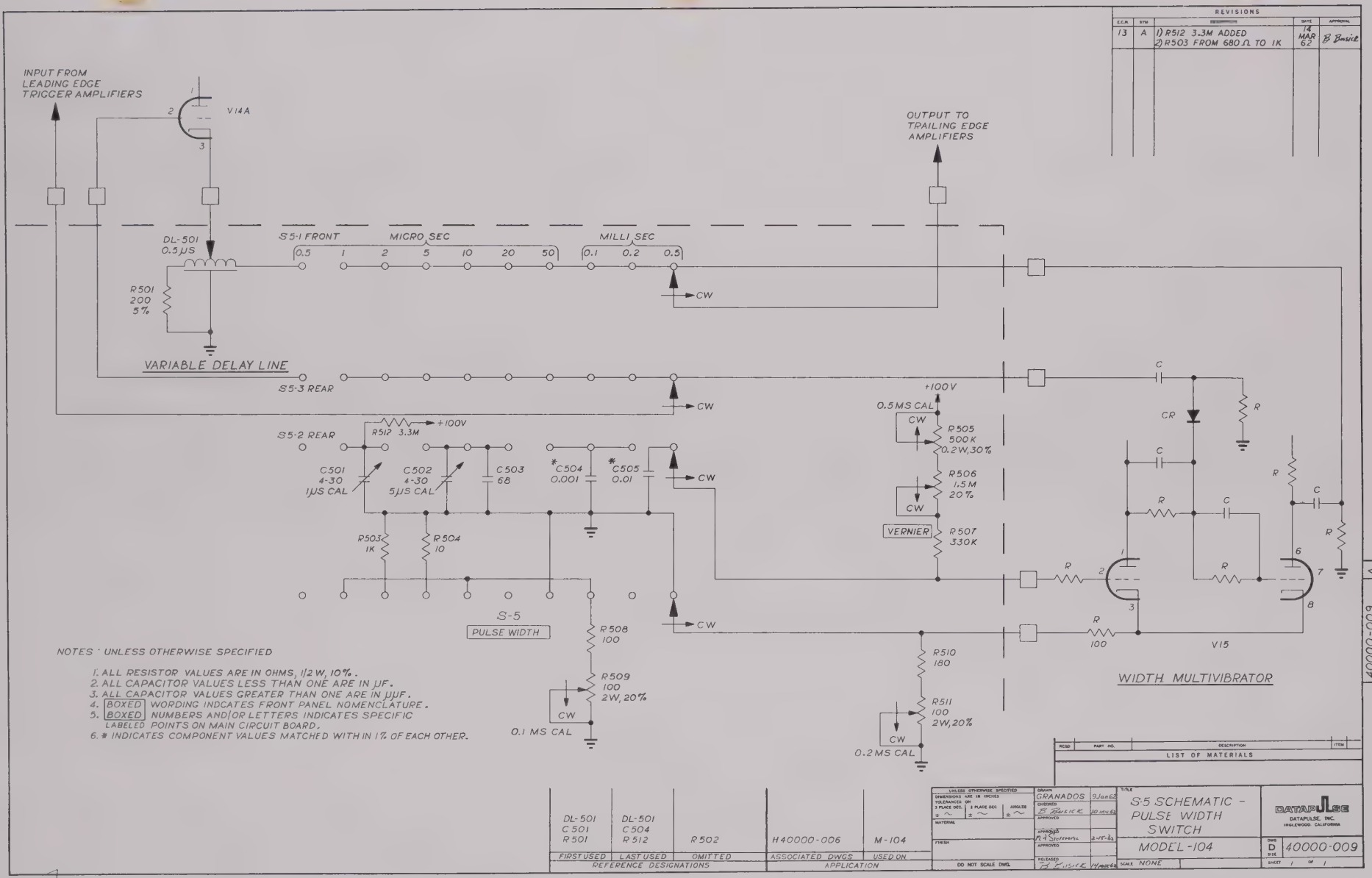
DRAWN GRANADOS 3 Jan 62
CHECKED B Burtch 8 Jan 62
APPROVED
APPROVED P.A. Stockmeyer 8-16-62
APPROVED
RELEASED B Burtch 14 MAR 62
SCALE NONE

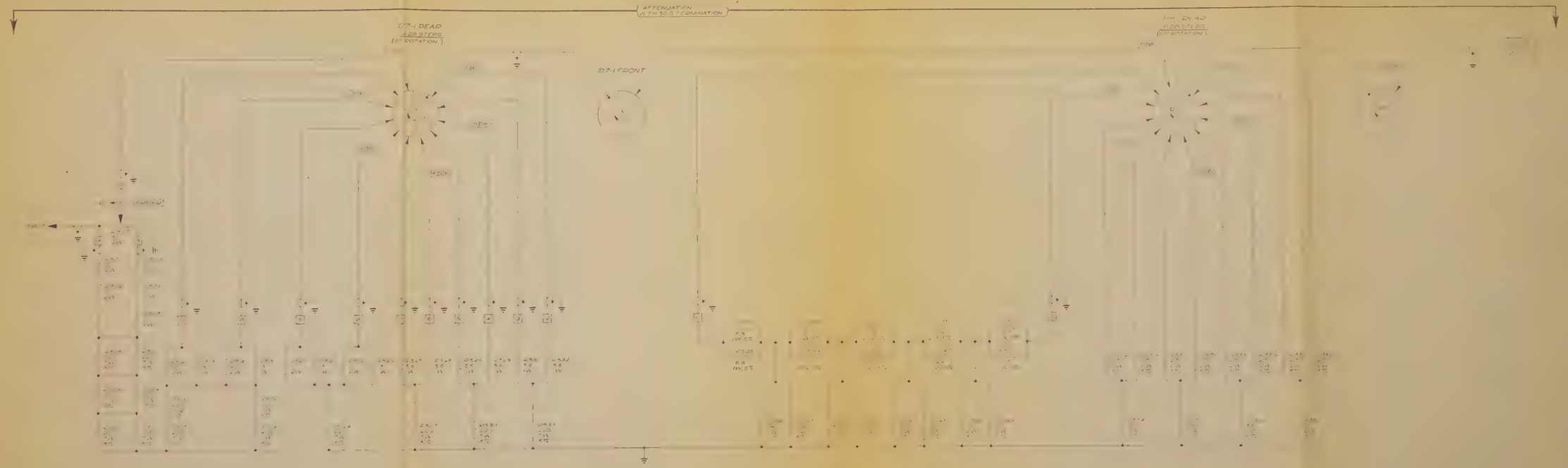
TITLE: S4 SCHEMATIC - PULSE DELAY SWITCH
MODEL - 104

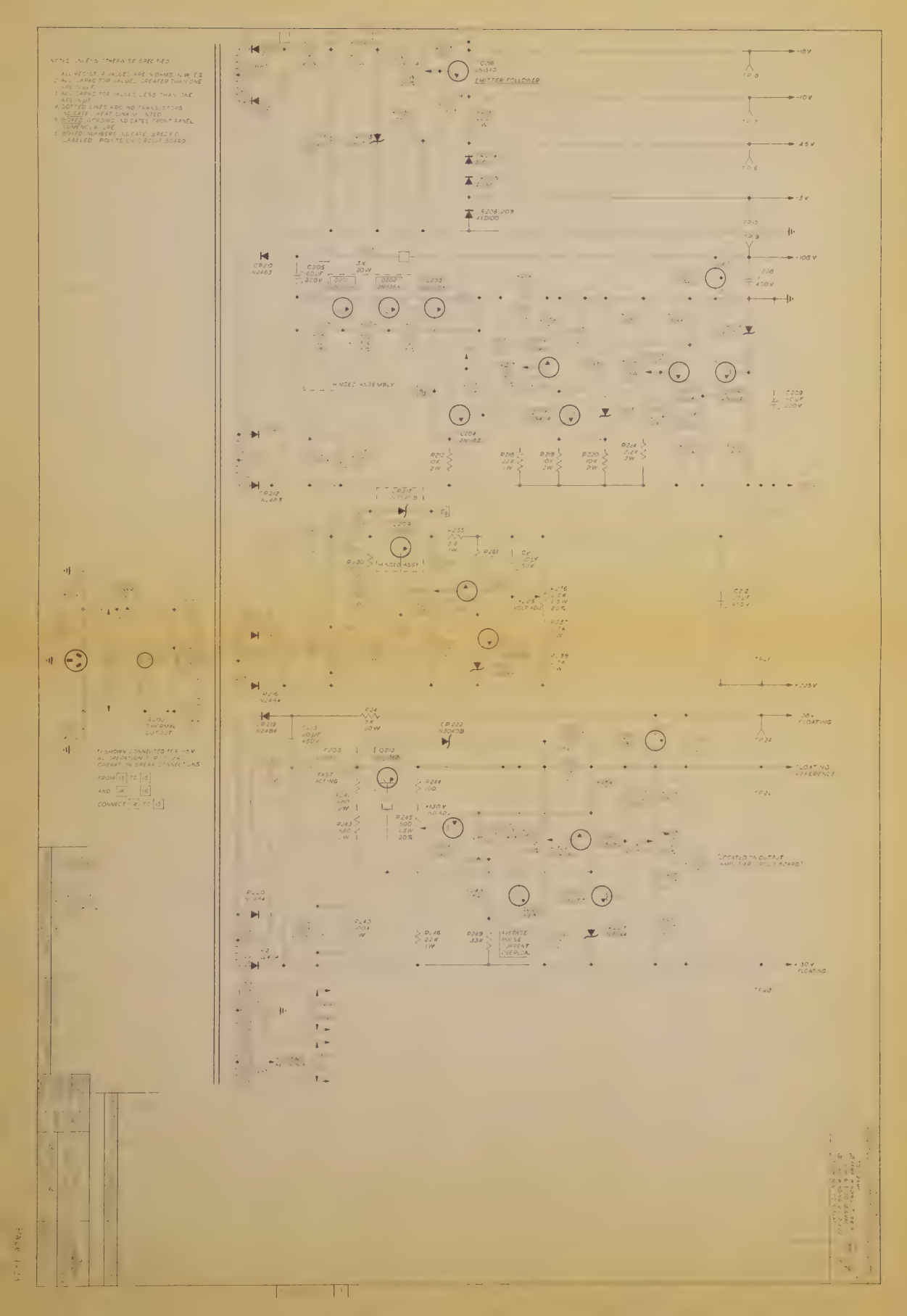
DATAPULSE, INC INGLEWOOD CALIFORNIA

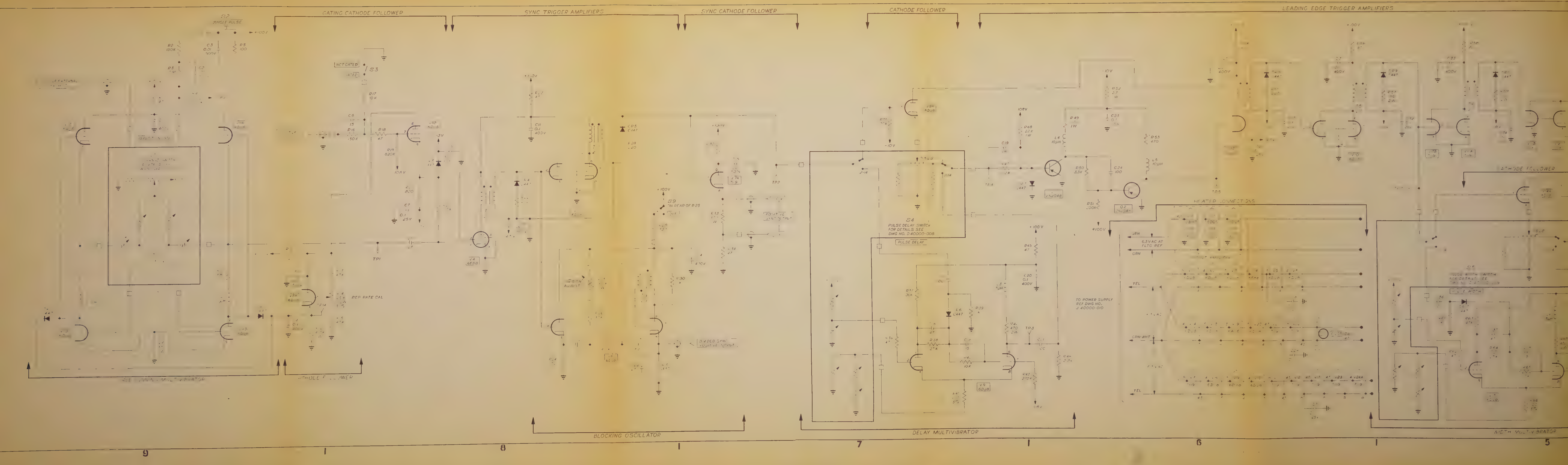
DWG 40000-008 A
SIZE D
SHEET 1 OF 1

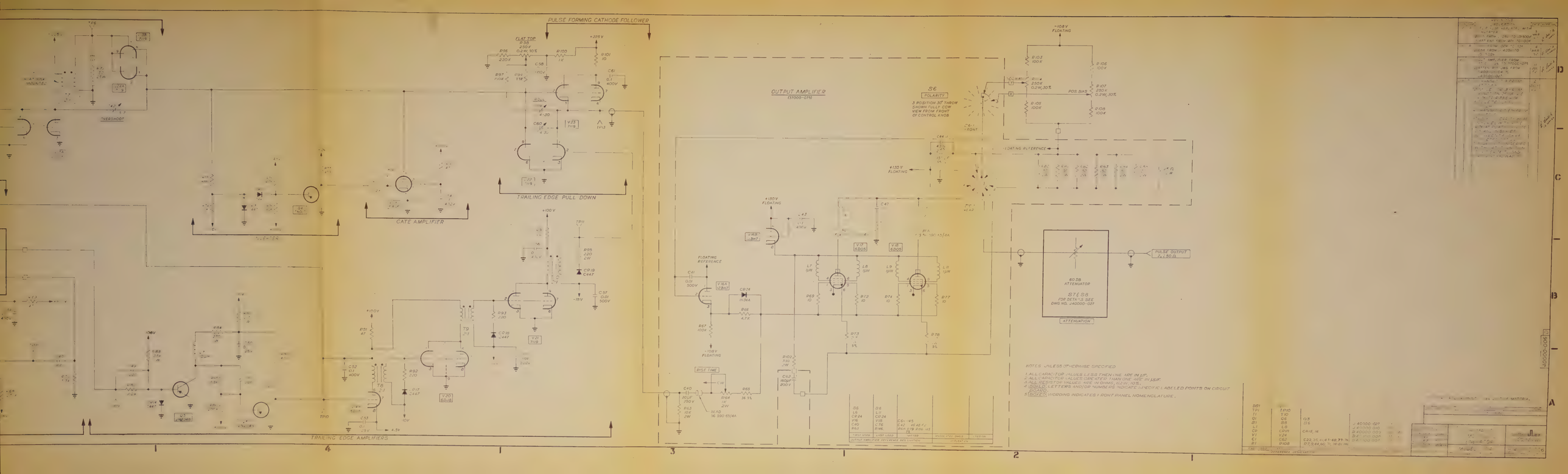
40000-008 A


REVISIONS
ECN 13 STN A
1) R512 3.3M ADDED
2) R503 FROM 680Ω TO 1K
DATE 14 MAR 62
APPROVAL B Basile
INPUT FROM LEADING EDGE TRIGGER AMPLIFIERS
V14A
OUTPUT TO TRAILING EDGE AMPLIFIERS
DL-501 0.5 μS
R501 200 5%
S-5-1 FRONT
MICRO SEC
0.5 1 2 5 10 20 50
MILLI SEC
0.1 0.2 0.5
CW
VARIABLE DELAY LINE
S-5-3 REAR
S-5-2 REAR
R512 3.3M
+100V
C501 4-30 1μS CAL
C502 4-30 5μS CAL
C503 68
*C504 0.001
*C505 0.01
R503 1K
R504 10
S-5
PULSE WIDTH
R508 100
R509 100 2W, 20%
0.1 MS CAL
0.5 MS CAL
R505 500K 0.2W, 30%
R506 1.5M 20%
VERNIER
R507 330K
R510 180
R511 100 2W, 20%
0.2 MS CAL
R 100
V15
C
CR
R
WIDTH MULTIVIBRATOR
NOTES: UNLESS OTHERWISE SPECIFIED
1. ALL RESISTOR VALUES ARE IN OHMS, 1/2 W, 10%.
2. ALL CAPACITOR VALUES LESS THAN ONE ARE IN μF.
3. ALL CAPACITOR VALUES GREATER THAN ONE ARE IN μμF.
4. BOXED WORDING INDCATES FRONT PANEL NOMENCLATURE.
5. BOXED NUMBERS AND/OR LETTERS INDICATES SPECIFIC LABELED POINTS ON MAIN CIRCUIT BOARD.
6. # INDICATES COMPONENT VALUES MATCHED WITH IN 1% OF EACH OTHER.
LIST OF MATERIALS
REQD PART NO. DESCRIPTION ITEM
DL-501 C 501 R 501 | DL-501 C 504 R 512 | R 502 | H 40000-006 | M-104
FIRST USED | LAST USED | OMITTED | ASSOCIATED DWGS | USED ON
REFERENCE DESIGNATIONS | APPLICATION
UNLESS OTHERWISE SPECIFIED DIMENSIONS ARE IN INCHES TOLERANCES ON 3 PLACE DEC. ± 2 PLACE DEC. ± ANGLES ±
MATERIAL
FINISH
DO NOT SCALE DWG.
DRAWN GRANADOS 9 Jan 62
CHECKED B Basile 10 Jan 62
APPROVED
APPROVED M A Stefanko 2-15-62
APPROVED
RELEASED B Basile 2/16/62
TITLE S-5 SCHEMATIC - PULSE WIDTH SWITCH MODEL -104
SCALE NONE
DATAPULSE INC. INGLEWOOD, CALIFORNIA
DWG NO 40000-009
SIZE D
SHEET 1 OF 1
40000-009 A


ATTENUATION WITH 50Ω TERMINATION
S7-1 DEAD
4 DB STEPS
(45° ROTATION)
S7-1 FRONT
S1-4 DEAD
6 DB STEPS
(60° ROTATION)


NOTES UNLESS OTHERWISE SPECIFIED
1. ALL RESISTOR VALUES ARE IN OHMS 1/4W ±2%
2. ALL CAPACITOR VALUES GREATER THAN ONE ARE IN μF
3. ALL CAPACITOR VALUES LESS THAN ONE ARE IN μF
4. DOTTED LINES ARE NO TRANSISTORS
5. BOXED WIRING INDICATES FRONT PANEL NOMENCLATURE
6. BOXED NUMBERS INDICATE SPECIFIC LABELLED POINTS ON CIRCUIT BOARD
Q216 2N540 EMITTER FOLLOWER
CR206 209 4X2000
+18V
+10V
-45V
-3V
+108V
CR213 1N2483
C205 60μF 1.2 30V
K 20W
Q201
Q202 2N1136A
Q203
C208 450V
HINGED ASSEMBLY
Q204 2N1483
C209 10μF 200V
R210 10K 2W
R218 22K 1W
R219 10K 2W
R220 10K 2W
R224 22K 2W
CR212 1N483
CR217 1N2069
C209
R230 1W HINGED ASSY
R235 5.6 1W
R261
CK .01μF 50V
R216 15K 1.5W 20%
VOLT ADJ
C232 .1μF 450V
CR214 1N2484
C213 40μF 450V
CR215 1N2484
R24 5K 20W
CR222 MS2408
+135V
+30V FLOATING
FAST ACTING
R244 150
R245 500 1.2W 20%
R243 680 1W
R240 1.2K
R246 22K 1W
R249 33K
AVERAGE PULSE CURRENT OVERCAL
-30V FLOATING
SLOW THERMAL CUT OUT
TP1
TP2
TP3
TP4
TP5
TP6
TP7
TP8
TP9
TP15
TP23
TP24
+135V
-30V FLOATING
FLOATING REFERENCE
LOCATED ON OUTPUT AMPLIFIER CIRCUIT BOARD
AS SHOWN CONNECTED TO +135V
ALL OPERATION IS BY JACK CONNECTIONS
FROM 17 TO 13
AND 4 16
CONNECT 4 TO 15


GATING CATHODE FOLLOWER
SYNC TRIGGER AMPLIFIERS
SYNC CATHODE FOLLOWER
CATHODE FOLLOWER
LEADING EDGE TRIGGER AMPLIFIERS
S2
SINGLE PULSE
+100V
R2 150K
C3 0.01 500V
R5 100
NOT GATED
S3
R17 10K
C6 15
R16 150K
R18 47
R19 820K
108V
-3V
C11 0.1 400V
C7 0.1 25V
TP1
REP RATE CAL
CR5 C447
S9 ON REAR OF R25
TP2
S4
PULSE DELAY SWITCH
FOR DETAILS SEE
DWG NO. D40000-008
PULSE DELAY
-10V
R48 22K 1W
L4 10µH
R49 1W
R52 2.7 W
R53 470
L5 10µH
R50 3.3K
C24 100
R51 100K
TP5
400V
CR9 C447
C33
6.3VAC AT
FLTG REF
GRN
YEL
GRN-WHT
TO POWER SUPPLY
REF DWG NO.
J 40000-010
R45 47
C20 0.1 400V
TP3
R43 270K
R38 27K
R39
V9 6DJ8
BLOCKING OSCILLATOR
DELAY MULTIVIBRATOR
9
1
8
1
7
1
6
1
5


PULSE FORMING CATHODE FOLLOWER
FLAT TOP 0.1µs 250K 0.2W 10%
OVERSHOOT
GATE AMPLIFIER
TRAILING EDGE PULL DOWN
TRAILING EDGE AMPLIFIERS
OUTPUT AMPLIFIER (37000-075)
S6 POLARITY
3 POSITION 30° THROW SHOWN FULLY CCW VIEW FROM FRONT OF CONTROL KNOB
FLOATING REFERENCE
PULSE OUTPUT Z₀ = 50 Ω
60 DB ATTENUATOR
S7, S8
FOR DETAILS SEE DWG NO. 340000-027
ATTENUATION
NOTES: UNLESS OTHERWISE SPECIFIED
1. ALL CAPACITOR VALUES LESS THEN ONE ARE IN µF.
2. ALL CAPACITOR VALUES GREATER THAN ONE ARE IN µµF.
3. ALL RESISTOR VALUES ARE IN OHMS, 1/2W, 10%.
4. (BOXED) LETTERS AND/OR NUMBERS INDICATE SPECIFIC LABELLED POINTS ON CIRCUIT BOARD.
5. (ROUNDED) WORDING INDICATES FRONT PANEL NOMENCLATURE.
340000-005

INSTRUMENT CERTIFICATION

MODEL 104 SN#_____

Instrument has been aged for 24 hours and fully calibrated prior to this test. _____

REPETITION RATE

Oscilator Covers 5 CPS to 10 MC _____

Accuracy ± 10% _____

No Holes in Vernier Coverage _____

Jitter ≤0.02% _____

EXTERNAL TRIGGER

5V RMS Drive Required from 10 CPS to 1 MC _____

+5V Pulse Drive Required from 0 CPS to 10 MC. _____

SINGLE PULSE

Each depression of push button provides one cycle of output _____

GATING

20V Positive gate required _____

SYNC PULSE

Amplitude>10V into 100 ohm at 10 MC _____

MAIN PULSE DELAY

Delay covers 0.05 μs to 10MS _____

Accuracy ±5% _____

No "Holes" in Vernier Coverage _____

Max duty cycle ≥70% _____

Jitter ≤0.1% _____

MAIN PULSE DURATION

Duration covers 0.02 μs to 0.5 MS _____

Accuracy ±5% _____

No "Holes" in Vernier Coverage _____

Jitter ≤0.1% _____

MAIN PULSE OUTPUT

Amplitude ≥40V delivered into 50Ω load, to 8 mc (Positive and negative) decreasing 10% @10 mc _____

Attenuator Accuracy ±10% _____

WAVEFORM

Overshoot variable to≤5% _____

Rise time variable to 0.2 μs _____

Top slope variable to ≤3% _____

Rise time ≤10 nanoseconds. (Pos. & Neg.) _____

Neg.)

Decay time ≤10 nanoseconds (Pos. & Neg.) _____

I certify that this instrument meets all of the above specifications and conforms to DATAPULSE Standard 91200-000 for workmanship and appearance.

SIGNED_____ Date_____

Final Test Inspector

WARRANTY

Datapulse Incorporated warrants each instrument of its manufacture to be free from defects in material and workmanship. Our obligation under this Warranty is limited to servicing or adjusting any instrument returned to our factory for that purpose, and to making good at our factory any part or parts thereof except tubes, transistors, fuses or batteries which shall, within one year after making delivery to the original purchaser, be returned to us with transportation charges prepaid, and which our examination shall disclose to our satisfaction to have been thus defective.

Instruments returned under this Warranty will not be accepted at the Datapulse plant without prior authorization by a Datapulse representative or by the service manager of Datapulse Incorporated.

Datapulse Incorporated reserves the right to make changes in design at any time without incurring any obligation to install same on units previously purchased.

This Warranty is expressly in lieu of all other obligations or liabilities on the part of Datapulse Incorporated and Datapulse Incorporated neither assumes nor authorizes any other person to assume for them any other liability in connection with the sales of Datapulse Incorporated instruments.

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